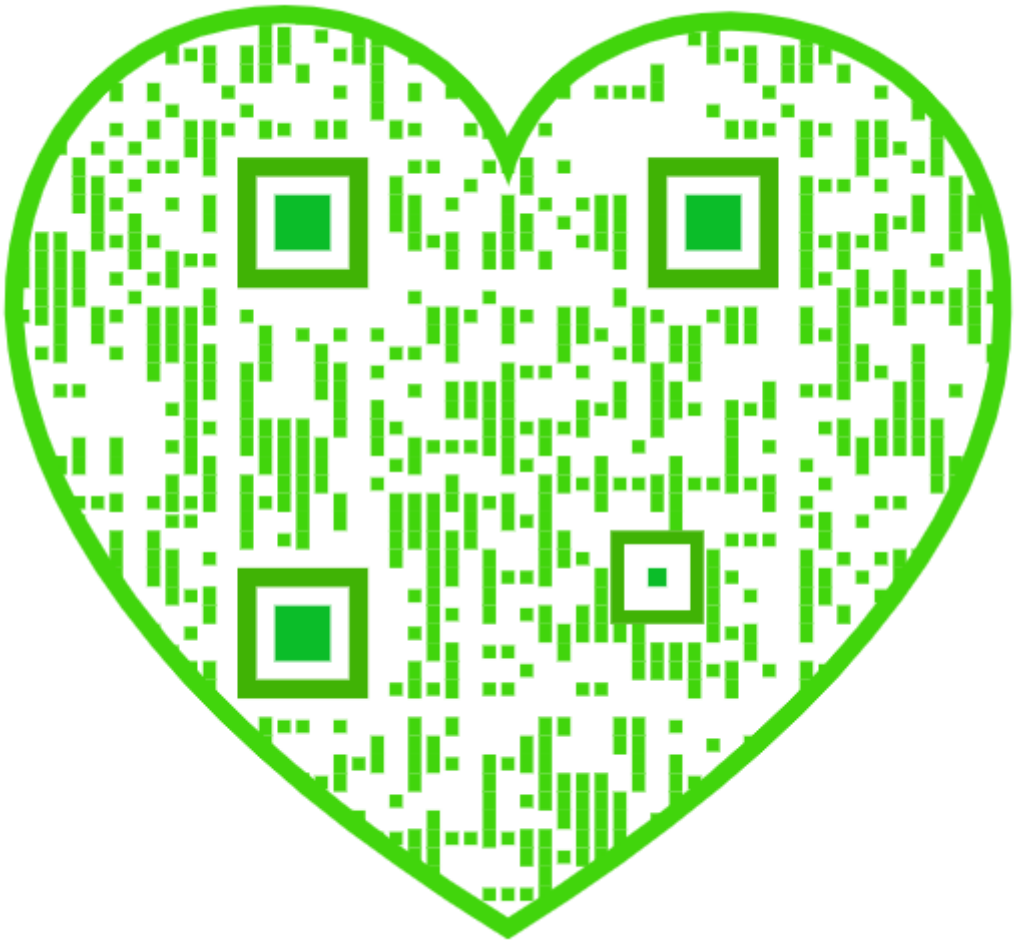

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A MANUAL OF SURGICAL ANÆSTHESIA

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A MANUAL OF SURGICAL ANÆSTHESIA

BY

H. BELLAMY GARDNER

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'To endeavour to determine some constant, general and irrefragable laws of right.'—RUSKIN: Introduction to *The Seven Lamps of Architecture.*

SECOND EDITION

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PREFACE TO THE SECOND EDITION

I HAVE remodeled, and in parts rewritten, this book for the present edition, especially the chapter relating to the Cardinal Principles for Anæsthetic Administration. Several chapters of new material describing the methods of producing spinal analgesia, ether infusion, and intratracheal insufflation anæsthesia, and also the system of anoci-association, have been added, with new figures and plates to illustrate them.

I am sincerely desirous that the main teaching of this work in emphasizing the importance of maintaining the freedom of the airways during anæsthesia should still form its chief recommendation to the student and practitioner.

I beg to thank Messrs. Allen and Hanburys for their assistance in the preparation of the new plates, showing some useful accessories for the major operations, and Messrs. Mayer and Meltzer for their loan of blocks for the figures of new apparatus.

H. BELLAMY GARDNER.

126, HARLEY STREET,
LONDON, W.
January, 1916.

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PREFACE TO THE FIRST EDITION

This book has been written in order to set out clearly for the student and practitioner of medicine the principles upon which the art of inducing general surgical anæsthesia is founded, and the best methods by which the art may be developed.

I venture to hope that it may be read through from beginning to end in three sittings, so that the reader may be interested more in the bearing of medicine and surgery upon the subject, than perplexed by the mechanical detail of apparatus, which will be better understood by demonstration. The student of this subject must be practically trained by constantly administering anæsthetics himself under skilled supervision, until he knows by ear, as a motorist knows of changes in the working of his engine, the different sounds produced by inspiration and expiration through clear or partly obstructed airways, for without this faculty in the administrator anæsthesia can be neither safe nor tranquil.

I have thought it well not to discard the word "asphyxia" completely, because from past association it recalls a mental picture of the condition indicated which is not yet created by the more correct word "anoxæmia," though it is desirable that this should in time replace it.

A considerable space has been devoted to the requirements of dental surgery, because it is probable that more work of this kind will fall to the practitioner

as the serious sequelæ of oral sepsis become more clearly recognized.

I am desirous of acknowledging my obligation to Dr. Frederic W. Hewitt for his kind permission to publish illustrations of the apparatus which he has designed, and also, as my original instructor, for his greatly valued tuition in this special branch of practice.

I am particularly grateful to Mr. Frederick C. Wallis, F.R.C.S., for the facilities which he afforded me for the use of the open ether method, and for the study of certain positions of the patient in anæsthesia during his operations for rectal diseases at St. Mark's Hospital for Fistula.

I am personally indebted to Mr. C. Robbins, L.D.S., who granted me the use of one of his consulting-rooms, and the dental appliances required to obtain the photographs illustrating methods of administering nitrous oxide and oxygen.

My colleague, Dr. Bernard E. Potter, has kindly made many literary suggestions for these pages, of which I have gladly availed myself, and for which I offer him my best thanks.

I wish to thank Messrs. Allen and Hanburys, of 48, Wigmore Street, W., who have provided me with a large number of illustrations of the apparatus and instruments described, and kindly made arrangements for other photographs to be taken in their model operating-theatre. Also Messrs. G. Barth and Co., of 54, Poland Street, Oxford Street, W., who have assisted with new illustrations of anæsthetic apparatus; Mr. J. H. Montague, who lent the arm-rest shown in Plate X.; Messrs. Down Brothers; Krohne and Sesemann; John Bale, Sons and Danielsson; and Mr. J. J. Griffin, for the loan of drawings.

H. BELLAMY GARDNER.

126, Harley Street,
London, W.
July, 1909.

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A MANUAL OF SURGICAL ANÆSTHESIA

CHAPTER I

THE HISTORY OF SURGICAL ANÆSTHESIA

THERE can be little doubt that the idea of an anæsthetic state occurred to man in very early times. It seems more than likely that the analogy between natural sleep, in which the tactile sensibility is impaired, and the desirable condition for a patient about to be cut or cauterized, must have suggested itself to those who first used the scalpel and the burning-iron upon their fellow-beings in the endeavour to cure disease.

Homer, in the "Odyssey," says: "Helen dropped into the wine of which (the soldiers) drank a drug, an antidote of grief and pain, inducing oblivion to all ills. He who drinks of this mingled cup sheds not a tear the livelong day: were death to seize his venerated sire, or her who gave him birth, or were the sword buried in the bosom of his brother or greatly loved sister, no tear would even then bedew his cheeks."

Herodotus, who lived 484 B.C., makes reference to the practice of the Scythians of inhaling the vapours of a certain kind of hemp to "produce intoxication." Indian hemp, or *Cannabis indica*, produces an exalted mental state and subsequent sleep, and is smoked under the name of "haschish" by the Arabians of the present day.

From an old Chinese manuscript it appears that a

physician named Hoa-Tho, who lived in the third century, gave his patients a preparation of hemp, "whereby they were rendered insensible during the performance of surgical operations."

Clear accounts of narcosis under operation do not appear till we find, among the writings of the physicians of the Roman Empire, evidence of the routine use of the lethargy produced by drinking an infusion of *Atropa mandragora*, commonly called the "mandrake," a vegetable product of the isles of Greece, in action and botanical genus closely allied to the belladonna of our own Pharmacopœia.

Dioscorides Pedanius, for instance, who lived in the early part of the first century, mentions it in these words:

"There are those who boil the root in wine to a third part, and preserve the decoction, of which they give a cyathus (a small drinking-glass) in want of sleep, or severe pains in any part; and also before operations with the knife or actual cautery, that they may not be felt." He speaks of "a wine made from the bark of the root, used for those who are about to be cut or cauterized, when, being thrown into a deep sleep, they do not feel any pain." "It could," he said, "be also introduced into a cake or other food, and afterwards produce an infatuation, taking away the use of the reason, the person sleeping in the attitude in which he ate the cake for three or four hours afterwards."

Pliny, the Roman author, who lived between A.D. 23 and 79, says the juice of the leaves will produce sleep, and is "taken against serpents, and before cuttings and burnings, that they may not be felt. He says (and this is a prototype of the present method of narcosis induction): "For these purposes it is sufficient for some persons to

seek sleep from the smell." In another place he states that the seeds of the rocket-plant (*Eruca*), when drunk infused in wine, by criminals about to undergo the lash, produce a certain callousness or hardihood of feeling (" duritiam quandam contra sensum induere ").

Galen, the physician, born at Pergamos, in Mysia, in A.D. 134, who afterwards practised in Rome and Alexandria, makes mention of " the power of mandragora to paralyze sensation and motion."

Lucian, a Greek historian, in the middle of the second century, says, in his praises of Demosthenes: " He rouses his fellow-citizens, unwilling to be disturbed, as if put to sleep by mandragora, employing his outspokenness as a sort of cutting and cauterization of their apathy."

Ætius, the Greek physician, writing at the end of the fifth century, remarked that when an overdose of mandragora was given " danger was present when the patient kept constantly drawing in air through his mouth, gasping for breath; and if help was not soon afforded, he died convulsed." This reference is practically the last from the voluminous writings of the classical authors, and not again until the middle of the twelfth century has any really definite passage been found relating to the subject; but at this time a Tuscan physician of noble birth, by name Hugo de Lucca, prepared a certain oil " with which," he said, " by means of smelling alone, he could put patients to sleep on occasion of painful operations which they were to suffer."

Dr. Snow,[1] having examined the prescription for this oil, announced his " utter disbelief that a sponge containing the oil prepared as above would, after being placed in hot water, give off any odour or vapour that

[1] " On Chloroform and Other Anæsthetics," 1858, p. 6.

would cause insensibility." He thought that, " if sleep were really caused in this way, it must have been by some of the moisture from the sponge reaching the mouth or throat and being swallowed," giving as his reason for this view that hemlock, the main ingredient of the oil, is not sufficiently volatile for inhalation.

He also remarked:

" There is another reason for disputing the efficiency of the above-mentioned receipts.

" Theodoric, who lived some time with Hugo de Lucca, and saw his practice, directs the patients about to undergo operations to be tied or held by strong men.

" In operations for hernia, for instance, he teaches that the patient must be tied to the bench or table with three bands, one round the ankles, another round the thighs, and a third across the chest, holding the arms and hands.

" It is reasonable to conclude that, if there had been any really successful method of preventing pain during surgical operations in vogue after the revival of learning and literature, it would not have fallen into disuse and been forgotten."

But, in returning to the Middle Ages, I think we are driven to the conclusion that by means of some narcotic drug, or even inhalation (for they are mentioned familiarly by the poets of this time), surgeons were able to reduce their patients to at least some degree of anæsthesia previous to operation.

Take this passage from Du Bartas' works, written in 1544:

> " Even as a surgeon, minding off to cut
> Some cureless limb, before in use he put
> His violent engines on the vicious member;
> Bringeth his patient in a senseless slumber,
> And griefless then, guided by use and art,
> To save the whole, cuts off the affected part."

In a work by Andrew Borde, called "The Breviare of Health," written in London in 1547, "a candell of wax with henbane seeds, which must be lighted so that the perfumes of the candell do enter into the tooth," was recommended by him for the cure of toothache.

A scene from Shakespeare's "Cymbeline," dating about the year 1613, seems to bear a meaning of this nature; note also the curious reference to experiments upon living animals.

Cornelius, the Court physician, is asked by the Queen for poisonous drugs, intending to use them on her enemies.

The Queen says:

"I will try the forces
Of these thy compounds on such creatures as
We count not worth the hanging (but none human),
To try the vigour of them, and apply
Allayments to their act; and by them gather
Their several virtues and effects."

Cornelius answers:

"Your highness
Shall from this practice but make hard your heart.
Besides, the seeing of these effects will be
Both noisome and infectious."

He withholds the deadly poison and substitutes another, which he tells the audience (aside):

"Will stupefy and dull the sense awhile,
Which first perchance she'll prove on cats and dogs,
Then afterwards up higher; but there is
No danger in what show of death it makes,
More than the locking up of spirits for a time,
To be more fresh reviving."

Cymbeline, Act I., Scene vi.

Dr Buxton[1] says: " In the sixteenth and seventeenth centuries Valverdi and others operated upon patients stupefied by compression of the carotid arteries, so depriving the brain of blood. In this practice they seem to have been anticipated by the Assyrians, who are reported to have compressed the vessels of the neck to render painless the operation of circumcision."

An English surgeon named James Moore, in 1784, suggested, or revived a suggestion, that compression of the nerve trunks should be practised before cutting the areas supplied by them; and John Hunter carried out this method, and amputated a patient's leg at St. George's Hospital after firmly compressing the crural and sciatic nerves of the limb, and Mr. Moore expressed satisfaction at the result.

A certain renaissance of chemical research in the eighteenth century brought about the discoveries which have culminated in our knowledge of the anæsthetic agents of the present day; for in 1758 Dr. Michael Morris explained the method of preparing sulphuric ether to a Society of Physicians in London (the nucleus, I believe, of the present Medical Society), and related three cases in which he had cured lumbago and rheumatism by rubbing it over the affected parts; and another experiment in which a little dog was revived from a state of paraplegia by pouring a teaspoonful down its throat. " The dog," he said, " got up and ran about the room; ultimately, however, it died from the paralysis."

Hales, Lavoisier, and Cavendish, about this time, began their researches among the gases, and in 1772 Priestley added nitrous oxide to the list, which already included oxygen, nitrogen, and nitric oxide.

[1] Dr. D. Buxton, " Anæsthetics," 1900, p. 3.

The medical world was evidently bitten with the notion of therapeutic vapours, for in 1795 Dr. Pearson, of Birmingham, was employing ether as an inhalation for the relief of asthma; and in 1798 Dr. Beddoes inaugurated a Pneumatic Institute at Clifton, where he proposed to treat phthisis and many other diseases by inhalations of various gases.

Mr. Humphry Davy (who had been engaged by Dr. Beddoes as his assistant) inhaled nitrous oxide on one occasion, when suffering from the pain of cutting a wisdom-tooth, and found it considerably modified while he was under the influence of the gas.

He suggested that, " as nitrous oxide in its extensive operation appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place."

In 1806 Dr. Woolcombe, of Plymouth, prescribed ether for Lady Martin (wife of the Admiral of the Fleet), who was suffering from asthma. " About two teaspoonfuls of sulphuric ether were poured into a saucer, which was placed on her lap. Over this she breathed, with a shawl thrown round her head to prevent the escape of vapour. " Very soon," she remarked, " a delightful sense of tranquillity ensued; she felt as if going to heaven in the heavenly way, and presently used to sink back unconscious."

In 1818 an article appeared (believed to have been written by Faraday, the great chemist and philosopher) in the English *Quarterly Journal of Science and Arts*, pointing out the resemblance between the effects of ether vapour and those of nitrous oxide gas. This article was soon afterwards quoted in many standard works on

chemistry, and it became the custom of the late Professor Turner, of University College, to pour a little ether into a bladder of air during his lecture upon it, and allow some of the students to inhale the vapour, and thereby demonstrate its narcotic properties.

Among many interesting facts recorded in the authorities I have consulted may generally be found a discussion upon the experiments of mesmerists or believers in animal magnetism, who sometimes procure a condition allied to anæsthesia by means of passes or strokings of the body of the patient, or merely, in some cases, by suggesting in words that he will not feel pain.

With this power Dr. Esdaile operated largely in 1841 upon Hindus in India, hypnotizing them, and operating during the subsequent condition of slumber. "It was, however, only in a portion of the cases in which it was tried that the alleged effects appeared. In many instances efforts continued for two or three months had no effect upon the patient, and in many of the operations reported as successful there was much convulsive movement of the limbs, corrugation of the brows, and even loud cries and sobs, although the patients afterwards denied all knowledge of what had passed."

At Jefferson, Georgia, U.S.A., on March 30, 1842, Dr. Crawford W. Long[1] administered ether to James M. Venable until he was profoundly unconscious, and removed a cyst from the back of the patient's neck without pain. Subsequently he used ether for operations on several occasions, but did not publish the fact until some years later.

Not till forty years after Humphry Davy's first trial

[1] Dr. Dudley Buxton, Proc. Roy. Soc. Med., 1912, vol. v., pt. i., p. 19.

of nitrous oxide as an anæsthetic was his suggestion put to the practical test; but at last, in 1844, Horace Wells, a dentist of Hertford City, Connecticut, U.S.A., attended a chemical demonstration by an itinerant lecturer named Colton, during which one of the audience inhaled an impure sample of nitrous oxide gas. He became very excited under its influence, and danced about the platform, wounding his leg against a form without being aware of it. This circumstance attracted Mr. Wells' attention, and he at once conceived the idea of using the gas as an anæsthetic for tooth extraction.

The next day the chemist Colton administered gas to Mr. Wells, and another dentist extracted one of his molar teeth without causing him any pain. Mr. Wells then employed gas successfully among his patients (as far as I can discover, simply by means of a bag containing the gas, with an exit tube for insertion in the patient's mouth, but with no kind of face-piece attached). He then attempted a public demonstration of the new anæsthetic at the Boston General Hospital, Massachusetts, U.S.A., but, his patient showing unmistakable signs of pain during the tooth extraction, he took this public failure much to heart and left the city. It was unfortunate that he did not exhibit the effects of the gas on more than one patient, as susceptibility varies in different subjects, and his nervousness no doubt prevented the proper administration of the anæsthetic in the single case then shown.

We come now to the eventful year 1846, when (gas having been quite discredited in the meantime) Dr. Morton, one of Mr. Wells' pupils, who remained in Boston after his teacher's discomfiture and retirement, was consulting with a scientific chemist named Jackson as to the mode of preparing nitrous oxide gas, and the latter

suggested the use of sulphuric ether vapour in its stead, as being more easily obtained. Acting upon this suggestion, Dr. Morton tried ether vapour upon two or three dental cases, and then gave a public demonstration in the Boston General Hospital on October 17 of that year, while Dr. Warren operated, and this time the anæsthesia was a complete success.

Dr. Morton tried to keep the nature of his anæsthetic liquid a secret, calling it simply "Letheon"; but Dr. Bigelow, of Boston, discovered by its smell that it was sulphuric ether, and sent the news to his friend, Dr. Boott, of London. Dr. Boott tried the administration of ether in his own house in Gower Street, London, the day after receiving this intelligence, while Mr. Robertson, a neighbouring dentist, removed some teeth from a patient without causing any pain. This operation, therefore, performed on December 19, 1846, was the first in which ether vapour was employed in England as an anæsthetic.

Two days later Mr. Squire administered ether to two patients in University College Hospital, by means of an apparatus he devised for the occasion; while the famous surgeon Liston amputated a thigh in the one case, and removed an ingrowing toenail in the other.

The late Mr. Jabez Hogg, who administered various anæsthetics over 6,000 times, and remembered these interesting events very distinctly, wrote: "A description of the first graduated dose inhaler for ether, which I had made, you will find was printed in the *Illustrated London News* for February, 1847. At this date I had fairly taken up the then most interesting question—the safe administration of ether and other anæsthetics—and it was in the same year I made the acquaintance of the late

Dr. Snow, and together we made a considerable number of experiments. The first death I saw—in, I think, 1848—was due to the administration of ether. I was hastily summoned to a neighbouring dentist's, who had the misfortune to administer an overdose to a gentleman he was about to operate on. The ether had been given with a clumsy form of mask inhaler."

On January 19, 1847, Dr. J. Y. Simpson, of Edinburgh, induced anæsthesia with ether during labour for the first time, and found that the contractions of the uterus were not inhibited, while the pains were entirely abolished.

He met with great opposition from the clergy, and even some members of the medical profession, who considered it to be unnatural and contrary to the laws of Christianity to mitigate the pains of labour; and published a very forcible and closely reasoned answer to these religious objectors, in the course of which he said:

"Some thoughtlessly argue that the employment of anæsthetic means, and the abrogation of pain in labour, must be irreligious because it is 'unnatural.' They seem to think that it looks as if we fancied that Nature, or rather that the God of Nature, had made the function of parturition in some respects imperfect or improper in its mechanism. These same individuals strangely forget that they themselves do not think it 'unnatural' to assist and supplement other physiological functions of the body. They wear clothes to assist the protecting influence of the skin, and do not think that 'unnatural.'"

"They use cookery and condiments to aid the functions of mastication and digestion. Is this because they think the functions of mastication and digestion imperfect in their formation and mechanism?

" They constantly ride in coaches. Is the function of progression imperfect in man ?

" ' How unnatural,' exclaimed an Irish lady to me lately, ' is it for you doctors in Edinburgh to take away the pains of your patients when in labour !' ' How unnatural,' said I, ' is it for you to have swam over from Ireland to Scotland against wind and tide in a steamboat ! . . .' They forget that it is God who has endowed man with mental powers calculated gradually to enable him to extend his knowledge and improve his earthly condition, and that this extension and this improvement are so far evidently allowed and willed by God Himself."

After this ether became generally used, was adopted in Paris, and the knowledge of its properties soon spread to all parts of the world where surgery was practised.

Ether was exhibited for eleven months in Europe, and for about sixteen months in America, before chloroform was introduced.

Early in November, 1847, Dr. J. Y. Simpson, having found that ether was somewhat irritating to the bronchial mucous membrane, and at times caused considerable excitement before anæsthesia was attained, was looking about for some less pungent vapour in its stead, and in conversation with Mr. Waldie, a scientific chemist of Liverpool, chloroform was suggested to meet the difficulty. A medicine called " chloric ether " had been in use since 1831 as a carminative, and its vapour had even been tried as an anæsthetic by Dr. Bigelow, of Boston, but without success. Dr. Simpson immediately tried pure chloroform upon some thirty cases, and read a paper before the Medico-Chirurgical Society of Edinburgh on November 10, entitled " Notice of a New Anæsthetic

Agent as a Substitute for Sulphuric Ether in Surgery and Midwifery."

With the many advantages indicated by Dr. Simpson for the use of chloroform, it very rapidly acquired a great reputation, and began to steadily supplant ether as a general anæsthetic. For about two months it was believed to be a perfectly safe one, but a woman, named Hannah Greener, died suddenly under its influence on January 28, 1848, near Newcastle-on-Tyne; and then from time to time, as a death was reported under chloroform, a general reversion, especially in England, took place in favour of ether.

Many of these early deaths under chloroform happened to patients about to undergo quite trivial operations, for which they were not specially prepared by abstinence from solid food and loosening of the clothing, nor were they even made to assume the recumbent position, and it was to the neglect of these precautions that some of these accidents were probably due.

Dr. Snow,[1] who had from the first been the administrator of anæsthetics at St. George's Hospital, thought that the vapour of chloroform should be well diluted with air, and that deaths occurred when it was allowed to enter the lungs in a concentrated form. He formed a good opinion of another vapour called " amylene " as a substitute, but did not consider it superior to ether and chloroform in selected cases; for he soon discovered that chloroform was more suitable for children and bronchial patients, while ether gave the best results in robust subjects or those whose heart muscle needed a stimulating inhalation.

[1] Author of the treatise " On Chloroform and Other Anæsthetics " (John Churchill, London, 1858).

The Royal Medico-Chirurgical Society sat in committee in 1864, and decided that ether was inconvenient as then administered, and insisted upon the danger of chloroform, unless given with 95 to 96 per cent. of air. Above this strength they considered the heart might be directly paralyzed by its entry into the pulmonary circulation.

Dr. Clover, afterwards anæsthetist at the Royal Dental Hospital of London, then contrived an apparatus by which this definite dilution of chloroform vapour could be attained, but owned subsequently that the ready applicability of the open method—*i.e.*, pouring chloroform on a towel held over the patient's face—was in all cases of more value than the supposed advantages of more complicated machinery.

Sir Benjamin Ward Richardson, about the year 1867, began to advocate the use of a drug he had discovered, called "bichloride of methylene," which was adopted and used extensively by Sir Spencer Wells at his abdominal tumour operations for many years subsequently. It closely resembled chloroform, but was considered less depressing, and had a very agreeable odour. It is now almost entirely out of fashion, as analysis has proved that, after a few hours' keeping, it is merely a mixture of alcohol with chloroform, and its high price was too severe a test of its value as an independent drug.

The American chemist Colton had before this come over to Paris and forced his nitrous oxide gas upon the attention of French dentists, until by the year 1867 he had a record of 20,000 successful administrations. In 1868, through the advocacy of a Dr. Evans (some liquid gas having been brought from France in iron bottles, much resembling those now in use), it was demonstrated for the first time publicly in London, at the Royal Dental

Hospital, then in Soho Square. A committee appointed to investigate its properties reported favourably upon it as " a safe and efficient anæsthetic for short operations "; and for such purposes it was very rapidly adopted by the profession.

In the year 1876 Dr. Clover first described his admirable apparatus for preceding the inhalation of ether by the administration of a little nitrous oxide gas, the difficulty with the former alone having always been its rather disagreeable smell, and the violent struggles of the patient before being rendered thoroughly unconscious.

Soon afterwards he perfected his " portable regulating ether inhaler," and the former obstacles to the exhibition of ether were thereby overcome.

In 1879 the British Medical Association concluded in committee at Glasgow that the blood-tension and heart's action were lowered and depressed by chloroform, and in 1889 the Nizam of Hyderabad granted a sum of money to Surgeon-Major Lawrie to investigate this question. The first Hyderabad Commission then appointed came to conclusions more favourable to the drug, being convinced, from experiments carried out on hundreds of small mammals, that the respiration nearly always failed first, before the heart ceased beating.

This report was so much at variance with English experience that a second Hyderabad Commission, in which Dr. Lauder Brunton, of St. Bartholomew's Hospital, took part, went over the experiments again, but they corroborated the decisions of the first Commission.

It is more than probable that the difference of climate largely influenced this result, as the chloroform vapour, which at northern temperatures is difficult to eliminate rapidly from the system, readily escapes in a tropical

atmosphere, and therefore, in cases of danger, removal of the anæsthetic produces a more immediate relief in the latter than in the former environment.

While investigating the influence of atmospheric pressure upon the inhalation of anæsthetics,[1] the author also came to the conclusion that " there was little doubt that in Hyderabad, 1,672 feet above sea-level, where the barometric pressure preserves a mean below 28 inches of mercury, the safety of chloroform is considerably enhanced."

The Anæsthetics Committee of the British Medical Association, after nine years' work, published a report in July, 1900, upon notes of 25,920 administrations, in which they stated that, " when danger occurs under chloroform, whatever its exact nature may be, there is abundant evidence that in a large proportion of cases the symptoms that are observed are those of primary circulatory failure."

Also " they are convinced that by far the most important factor in the safe administration of anæsthetics is the experience which has been acquired by the administrator."

A development in the administration of nitrous oxide gas was added to our resources by Sir F. Hewitt in the year 1886, by his design of a portable apparatus for its admixture with small percentages of oxygen for dental and other short operations.

The results of this method are exceedingly satisfactory in commanding a tranquil and sleep-like anæsthesia; the cyanosis and jactitation usually attending the use of pure gas are eliminated; while the available time for dental operations is distinctly prolonged.

[1] Transactions of the Odontological Society, February, 1904

In 1898 Mr. H. J. Paterson described in the *British Medical Journal* a series of surgical operations, the longest one two hours and ten minutes in duration, for which he had employed these mixed gases to induce and maintain the anæsthesia. In July, 1899, Mr. Paterson perfected his nasal apparatus for the administration of nitrous oxide gas during dental operations, and in 1906 the author adapted the double bag suggested by Dr. A. G. Levy, and also Sir F. Hewitt's mixing chamber to it, so that oxygen should be added to render the anæsthesia safer and more tranquil.

In the year 1900 Dr. W. J. McCardie, of Birmingham, translated a paper by Dr. Georg Lothiesen, of Innsbruck, "On Narcosis with Ethyl Chloride," which described the trial of this drug which he had made in 1896, and his adoption of it as an anæsthetic for short operations in general surgery. Dr. McCardie published an account of his own cases, which were the first attempted in this country, in 1901, and since then it has come into use for dental and other brief operations. Though more lethal than nitrous oxide, it seems especially useful in controlling fractious children and alcoholic subjects.

After this survey of the past history of anæsthetics, and their adoption as an auxiliary to the practice of the healing art in England, we can hardly refrain from remarking on the long intervals of time which elapsed between the discoveries of nitrous oxide gas and ether and the detection of their properties of annulling pain; for ether was prepared and used medicinally one hundred years, and nitrous oxide seventy years, before they were tamed and broken in to the service of surgery.

To clear the medical profession of this slur upon their acuteness and observation, may we not surmise that

there was so strong a repugnance on the part of patients to submit to experiments while physiology was so little understood, that it formed an almost insuperable obstacle to the proof of anæsthetic properties in those vapours by physicians of the time ?

Dr. Snow insisted that the use of anæsthetics by inhalation in the present day was entirely due to the notion of therapeutic gases which seized the medical profession at the end of the eighteenth century; but the references to surgical narcosis in the poets and writers of the Middle Ages above cited, at least 200 years before the establishment of Dr. Beddoes' Pneumatic Institute, are so astonishingly clear, and throw so much light on their general acceptance of such a possibility, that I believe our practice has arisen more from the use of mandragora by the ancients, inhalation being a development after rapid absorption by the pulmonary circulation had been demonstrated and suggested by those scientific chemists who put gas, ether, and chloroform, into the surgeons' hands.

CHAPTER II

THE DUTIES OF THE ANÆSTHETIST

The successful administration of an anæsthetic by inhalation to the human subject depends primarily upon the maintenance of efficient respiration; secondly, upon the regulation of the dose of the chosen drug; and, thirdly, upon the preservation of adequate circulation, blood-pressure, temperature, and vitality, within the patient's system in the various contingencies that may arise during unconsciousness. Unlike the lower animals, so liable is the human being to the supervention of numerous forms of respiratory embarrassment in the state of general anæsthesia that particular skill is required in foreseeing, discovering, and removing, the causes of hampered breathing and insufficient oxygenation of the blood.

The judgment which has been gained by experience in similar circumstances is recognized as so valuable that the services of a practised administrator are now deemed necessary in important cases, to relieve the operator of all responsibility with regard to the patient's general condition during the operation. The anæsthetist has thus, in many instances, to undertake duties of considerable gravity, and he should be thoroughly equipped, not only by medical qualifications, but physically, by possessing perfect senses of sight and hearing, keen scent, and gentle-

ness of touch. In addition to these, by previous tenure of responsible resident hospital appointments, he must first learn the methods of handling patients and dealing with them with tact and courtesy, and thus obtain the opportunities for the practice and development of his art which alone can provide him with facility and assurance, and the patient with intuitive confidence in his ability.

To his share fall the provision and accurate manipulation of the best drugs and apparatus for the administration of the different anæsthetic vapours; the detection of the symptoms and physical signs of disease, which will affect the subsequent anæsthesia; the choice of the particular anæsthetic or sequence of anæsthetics most suitable to the patient and operation in hand; the protection of the body from external harm; the regulation of the atmospheric temperature; the resort to stimulants and methods of resuscitation in cases of failing vitality; the safe transference to bed and supervision during recovery from insensibility. These tasks often involve no small tax upon his nervous energy and considerable call upon his time.

Though the administrator of the anæsthetic should not watch the operation from the surgical point of view, he should certainly be aware of all the major acts of the surgeon, of the occurrence of any complication, such as hæmorrhage, or the need of operative procedures other than those at first contemplated, which would require a more prolonged administration, for in these latter cases it may rest with him to decide whether the patient's condition is such that they may be safely undertaken.

It is wise, therefore, for every student and practitioner

to master the principles upon which anæsthetics may be safely administered, and the use of the best apparatus for the purpose, so that, when called upon to render a patient unconscious for an operation, he may have no doubt about the nature of his duties, nor timidity during their performance.

CHAPTER III

THE CARDINAL PRINCIPLES FOR THE CONDUCTION OF ANÆSTHETIC ADMINISTRATION

Though there is so great a difference in the age, size, general condition, temperament, and habits, of patients who require to be anæsthetized, derived as they may be from every class of the community, including both the alcoholic brewer's drayman and the fragile infant heir to a peerage, the actual and practical problem in every individual administration is not so much the proper dosage, which can be rapidly learned with ordinary judgment and care, as the avoidance and alleviation of the many forms of obstruction to air entry which constantly arise in the human subject in anæsthesia.

The preventable but frequently unobserved presence of varying degrees of intercurrent anoxæmia[1] due to obstructed respiration is the cause of most of the difficulties which beset the student in securing tranquil anæsthesia, and of a large percentage of the fatalities which have occurred in connection with anæsthetics in the past.

[1] The word "anoxæmia" (insufficient oxygenation of the blood) in preference to "asphyxia" (which literally means pulselessness) will be often used in this work to indicate the condition produced within the system by a partial or complete deprivation of the normal supply of oxygen to the blood.

CAUSES OF OBSTRUCTED BREATHING.

I. Partial Nasal Obstruction.

The nasal passages in the human subject, when perfectly clear and unobstructed, are adequate for respiration except in circumstances requiring deep and laboured breathing. For example, nasal respiration is frequently abandoned for mouth breathing by the average person while ascending a flight of stairs.

The tendency to do this shows that the nasal passages are inadequate in most cases to allow the passage of sufficient air to fill the lungs during deep and forcible respiration.

At one stage or another in anæsthesia respiration is almost certain to become deep and forcible, and we must add to this that a large proportion of otherwise healthy people do not possess clear and unobstructed nasal passages.

II. Venous Engorgement of the Air-Passages.

During general anæsthesia the lining membranes of the air-passages are liable to swell, owing either to direct action of the vapour inhaled, stimulated arterial circulation, or venous engorgement. The calibre of these passages is thereby reduced, and the presence of increased mucous secretion from their surfaces still further acts as a mechanical obstruction to the entry of air.

III. Masseteric Spasm.

During the induction stage of anæsthesia, tonic contraction of the masseter muscles almost invariably occurs,

which completely closes the mouth and oral airway, unless the teeth have previously been separated by a mouth-prop.

IV. Obstruction by the Lower Jaw and Tongue.

In the next stage, when relaxation supervenes, the lower jaw is no longer held in place, and, carrying the base of the tongue with it, tends to fall backwards and obstruct both the oral and nasal respiration, unless held forward by the administrator. The tongue muscle is also paralyzed in the surgical stage of anæsthesia, and in varying degrees, according to its size and the fixity of the tissues around it, tends to gravitate towards the pharynx and obstruct the entrance to the larynx.

V. Unsuitable Posture of the Patient.

There are certain postures in which anæsthetic sleep does not tend to produce mechanical obstruction to respiration in the human subject. These are—(1) The upright sitting position, with the head tilted a little forward; (2) the lateral position—*i.e.*, lying down upon the side, with the head turned a little towards the floor. In neither of these postures does the tongue fall backwards into the airway.

But in other postures external mechanical pressure may also impede the breathing: for in the prone position the weight of the trunk hampers the expansion of the chest unless the shoulders and pelvis are raised on pillows; in the lithotomy position the legs may exert pressure upon the abdomen and interfere with the inspiratory descent of the diaphragm; and even in the lateral position the weight of the upper arm may press too heavily upon that side and reduce the activity of the adjacent lung.

VI. Laryngeal Spasm.

Laryngeal spasm, evidenced by high-pitched and crowing inspiratory sounds, is quite a common occurrence in anæsthesia. It may be caused—(1) By the direct irritation of a strong vapour presented for inhalation, or by saliva, mucus, blood, or pus, finding its way towards the upper laryngeal aperture; (2) by reflex action as a preliminary to the act of vomiting, or as a result of surgical stimuli.

TREATMENT OF OBSTRUCTED BREATHING.

The first cardinal principle, therefore, is *to maintain a clear airway* in the anæsthetized subject.

The beginner should be taught that he must either *feel or hear every respiration* made by the patient, the mere watching for thoracic and abdominal movements being quite an inadequate safeguard; for these movements continue for a time after obstruction to the upper air-passages has taken place.

Stertor is the sound produced by partial obstruction in the airway, and all forms of stertorous breathing must therefore be abolished directly they arise.

To correct stertorous breathing, the chin must be raised, and the mandible (lower jaw) must be pushed forward, and maintained in that position by digital pressure upon the ramus, in order to carry the base of the tongue away from the pharynx. The mandible must also be kept in the central facial axis, as its slight lateral displacement is often responsible for obstruction to breathing, owing to the tonsil of the same side being pressed backwards into the airway between the tongue and pharyngeal wall.

If pushing the mandible well forward does not relieve stertor, the posture of the head must be altered, the latter perhaps being turned more to the side, perhaps extended farther backwards, until, by the clearer sound of the breathing, it becomes obvious that the airway is free again. If stertor still persist, the tongue itself should be gently drawn forward with a tongue-clip.

A strong vapour must, of course, be withheld and weakened when it has produced laryngeal spasm. Fluid of any kind must be ejected from the larynx by removal of the anæsthetic and encouraging a cough, or by drawing the tongue forward and sponging the throat. If a moderate amount of blood has blocked the larynx, a honeycomb sponge held in forceps should be passed into the back of the throat and rotated quickly, which will usually draw the clot out from the larynx and trachea.

A squeeze upon the sternum may also help in clearing the airway.

Spasm due to impending vomiting may often be relaxed by pushing the jaw well forward, rubbing the lips, and deepening the anæsthesia to the third degree.

Reflex spasm from surgical stimuli can sometimes also be diverted by rubbing the lips briskly with a towel and pushing the jaw forward. If it should become extreme, it will cease directly the stimulus ceases, and in this case the surgeon must be asked to desist momentarily from his manipulation.

Spasm is far less persistent under ether than under chloroform, and a change to ether may therefore in some cases prove of service. The hypodermic injection of $\frac{1}{6}$ grain of morphine may also be of great use in cases of persistent spasm by obtunding the transmission of peripheral stimuli.

These measures will be referred to and further explained in the chapters on the actual administration of the different anæsthetics; but in this place the rule is laid down that even a small degree of obstruction to free respiration must not be permitted to persist.

When rebreathing into a bag inhaler is proceeding, the movements of the bag will demonstrate by their amplitude whether respiration be obstructed or not; but only in this instance may his vision be relied upon with safety by the administrator as evidence of a clear airway in the patient.

The second cardinal principle is *to make absolutely sure of the exact degree of narcosis present* at any and every given moment of anæsthesia.

This involves the constant testing of the corneal lid reflex in order to ascertain whether *a weakly active closure of the upper eyelid* takes place on touching the centre of the cornea, a condition of absolute safety, which, by increase or diminution of the dose as required, should be maintained throughout until the conclusion of the surgical manipulations.

The depth of anæsthesia must, of course, be adapted to the requirements of the operator, more profound narcosis being necessary during strong surgical stimuli and *vice versa*. The practised anæsthetist becomes thoroughly conversant with every operation, and knows beforehand at what stages his most anxious moments will arise. In this place it is not possible to enumerate all those sensitive structures which give rise to rigidity, crowing respiration, and shock, during their manipulation, but they will be indicated in detail in subsequent pages.

In general terms, simple surgical incisions produce little disturbance of the patient unless the anæsthesia

be altogether too light. But any manipulation which involves stretching or dragging upon the tissues, or the exposure of large surfaces of internal parts to cold air, has a reflex effect upon the respiration and circulation of varying intensity, according to its force and duration.

The two cardinal rules above specified are not to be neglected for any other considerations, interruptions or emergencies whatever, as long as the patient remains in anæsthetic sleep.

It is the custom of many teachers to direct the student's chief attention to the condition of the patient's pupil during anæsthesia as next in importance to the sound of the breathing. But it is demonstrable that the pupil is affected by too many different stimuli for safe reliance to be placed either upon its size or reaction to light as a guide to the depth of anæsthesia.

The clearness of the airways and the presence of a weakly active corneal lid reflex being constantly maintained by the administrator, he watches the patient's face, which presents by its colour a mirror of the circulation beneath the skin; he sees the rise or fall of blood-pressure evidenced by rosy flush or fleeting colour of the cheeks, the degree of aeration of the blood shown by normal tint or purplish tinge of lips and ears, notes the appearance of the cold sweat of shock upon the forehead, and learns to forestall depression by remedial measures as these signs dictate.

The temporal and superior coronary pulses are at hand for further reference. Unusual slowness of beat marks the deeper stages of chloroform narcosis. Rapidity frequently associated with cyanosis indicates anoxæmia. Intermission and irregularity, and high rate with pallor, gives warning of impending failure of vitality.

FIG. 1.—DORSAL POSTURE: HEAD TO SIDE.

Anæsthetist pushing lower jaw forward from behind its angle to keep the tongue from touching the pharyngeal wall.

FIG. 2.—DORSAL POSTURE: HEAD TO SIDE.

Anæsthetist testing corneal upper lid reflex with pulp of middle finger.

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The condition of the muscular system should naturally be ascertained from time to time, reflex movements as a rule indicating a lighter anæsthesia than is appropriate. There are, however, some exceptions to this standard, for during the operation of circumcision in infants it is undesirable to run the risk of such profound narcosis as would abolish all tendency to slight flexion of the thighs when the prepuce is incised, and in operations upon the air-passages the coughing reflex should be retained.

CHAPTER IV

ANOXÆMIA AND ASPHYXIA

It is the object of this chapter to direct special attention to the importance of removing the numerous causes which tend towards the production of an asphyxial element during surgical anæsthesia; for if these were generally detected and eliminated as they arose, a far higher level of safety to the patient would be attained than in the application of remedial measures when a condition of danger has become pronounced.

The physiological effects of asphyxia in man should be closely studied by those who wish to become proficient administrators, because it is necessary to be intimately acquainted, not only with those symptoms which precede the appearance of asphyxia arising in an acute form, but more especially with those subtle phenomena which supervene when a process of more gradual deoxidation of the blood is at work within the patient's system.

The early perception of even very slight degrees of anoxæmia, and a knowledge of the proper methods of eliminating this factor, are among the most important accomplishments of the anæsthetist; for he should very clearly bear the fact in mind that during anæsthesia a condition in which oxygen is not gaining access to the system in adequate amount is fraught with very real danger to life in two distinct directions.

First, because the respiratory centre in the medulla after primary stimulation is depressed both by the action of the anæsthetic in the blood and by a state of anoxæmia. It is therefore more readily reduced in vitality by the two influences combined than by the former acting alone.

Secondly, particularly under chloroform, because of the rapid supervention of cardiac dilatation and paralysis when the cavities of the auricles and ventricles are laden with a drug which weakens their contractions, if the coronary vessels which nourish them are at the same time filled with venous blood.

The progressive stages of asphyxia which are to be observed in the human being when some exciting cause is at work in other circumstances are hardly to be expected, and are not, as a fact, exhibited in any marked degree in anæsthesia.

The appearance of hyperpnœa, dyspnœa, general convulsions, gradual exhaustion, and death, in ordinary conditions of disease, are apt in anæsthesia to be represented by laboured breathing, which grows shallow and irregular, and is followed by complete and sudden cessation of respiration, with cardiac failure in close attendance.

In anæsthesia general convulsions are exceedingly rare, and, unless anoxæmia be quite rapidly produced, such as by an overdose of nitrous oxide gas, they are not to be looked for during the production of an asphyxial death. It is possible, however, that slight clonic muscular movements of the shoulders and arms which sometimes occur in very profound chloroform narcosis, and also those which have been described as athetoid movements of the fingers and wrist-joints, may be of anoxæmic origin,

for they only precede respiratory failure by a very short interval.

Muscular rigidity, which under some circumstances is also a symptom of anoxæmia, is commonly witnessed during the second stage of anæsthesia under ether and chloroform, when a transient tonic contraction of the musculature occurs, which develops into a state of opisthotonos if air be not admitted to the lungs. Accompanied as it is by cyanosis, when this condition arises, the need for oxygen should be quite obvious even to the beginner.

The most minute observation should be directed to the behaviour of the respiratory system itself in the narcotic state, and its significance must be thoroughly mastered before it can be confidently stated that no asphyxial factor is at work at any given moment of the administration.

The exact import of **RAPID BREATHING** under an anæsthetic depends upon the stage at which it occurs. In the first and second stages of anæsthesia it is generally a voluntary effort caused by nervousness on the part of the patient; but if it should appear in the later phases of the third stage, it may be looked upon as representing the hyperpnœic condition, associated with a need for more air and less of the anæsthetic, the differentiation of these stages depending upon the brisk or weakly active condition of the corneal reflex at the time of its appearance.

It is commonly witnessed in cases with pyrexia, and the author has noticed it especially in the subjects of hepatic abscess.

DEEP BREATHING is the usual accompaniment of deep anæsthesia, and as long as it proceeds regularly without increasing in depth, and the amplitude of chest

movement is not exaggerated, it is the safest type of respiration to maintain. The two provisional conditions just mentioned must, however, be strictly observed, for when an asphyxial factor has been introduced, increasing depth of respiration is the first reflex effort of the respiratory system to obtain sufficient oxygen, and exaggerated thoracic and abdominal movement will be its outward manifestation. Deep breathing is also caused by powerful stimulation of afferent nerves on the part of the operator, such as may be produced by stretching the sphincter ani, dilating the urethra or the cervix uteri, dragging on the peritoneum or spermatic cord, or by interference with old-standing disease of large joints.

SHALLOW BREATHING is most commonly to be witnessed under chloroform, and is frequently accompanied by pallor and cyanosis. It is sometimes dependent upon too light a form of anæsthesia with impending vomiting; but in deeper stages of anæsthesia, when the corneal reflex is almost abolished, shallow breathing is a sign of approaching paralysis of the respiratory centre, and in this sense is itself an asphyxial factor.

The pallor which accompanies this kind of respiration is largely due to the lessened suction action of the feebly moving thorax upon the heart and venous system. That strong thoracic movement is a powerful factor in emptying the large veins may be frequently observed in witnessing operations which expose the internal jugular vein at the root of the neck, when this vessel is seen to partly flatten at each cardiac diastole during expiration, but to collapse completely during deep inspiration.

Shallow breathing should not, therefore, be permitted to continue; but either by rubbing the lips, which reflexly stimulates respiration, and deepening the anæsthesia in

the early stages, or, in the deeper stages, by withholding the anæsthetic, and making regular pressures upon the sternum till a more ample thoracic movement is produced, deeper automatic respiration can be established, and should afterwards be maintained.

IRREGULAR BREATHING is of very grave significance, and, excepting in the early stages before automatic regular respiration has set in, must be regarded also as a sign of impending central failure, and treated by a withdrawal of the anæsthetic and careful supervision of the freedom of the airway.

With this knowledge, variations in the rate and rhythm of the respiratory act should render valuable information as to the condition of the blood at any period of the anæsthesia. Other early signs of the presence of an anoxæmic factor are dependent upon commencing congestion of the venous system, and will be observed in alteration of the colour of the ears, which often look slightly bluish before any change is perceptible in the appearance of the lips or cheeks; in perspiration of the forehead and scalp; and in any undue oozing of blood from the operation wound, where changes in oxygenation can also be readily detected by the administrator.

With regard to congestion of the cutaneous and membranous surfaces produced by the presence of an anoxæmic factor in the blood, it is well to bear in mind that the respiratory tract especially is prone to engorgement arising from such a cause, and that this engorgement will further aggravate the condition of anoxæmia by presenting mechanical obstruction to the ingress of air owing to the resulting increase in size of the mucous lining of the air-passages, and of the tonsils, tongue, and other neighbouring structures.

THE STAGES OF ANÆSTHESIA.

	Respiration.	*Corneal Upper Lid Reflex.*	*Pupil.*	*Colour.*	*Pulse.*	*Blood-Pressure.*	*Laryngeal Sensitiveness.*	*Vomiting Centre.*	*Muscular System.*
STAGE I. *Disordered Consciousness.*	Voluntary, but may be "held."	Brisk.	Variable.	May be pale from fear.	May be rapid from fear.	May be low from fear.	Coughing from pungent vapour or fluid irritation.	Rarely affected.	Voluntary movements.
STAGE II. *Excitement.*	Deeper and quicker; may be hampered by jaw spasm.	Brisk.	Often dilated.	Improving except during impending sickness.	Steadier, improving in volume.	Rises markedly.	Active swallowing and coughing; dulled in conditions of septic intoxication.	Centre irritated; vomiting occurs unless stage regularly deepened.	Involuntary movement; struggling; tonic and clonic spasm.
STAGE III. *Surgical Anæsthesia.*	Regular and automatic, with stertor from tongue, etc., unless relieved.	Weakly active.	Of moderate size.	Normal or flushed; if blue, air is needed.	Full, strong, regular: ether, 90 per minute; chloroform, 64 per minute.	Normal under ether and N_2O+O; falls under chloroform; falls in feet-down positions.	Generally inactive and insensitive in latter half of this stage; but reflex spasm occurs from distant stimuli.	Centre paralyzed; but regurgitation of gastric contents possible in abdominal distension.	Striped muscles relaxed unless stimulated.
STAGE IV. *Profound Narcosis.*	Less regular, weaker in amplitude and fading away or ceasing suddenly after a few deep-drawn inspirations.	Absent.	Widely dilated.	Pale or of dusky pallor.	Rapid, weaker, irregular or intermittent.	Paralyzed.	Paralyzed.	Paralyzed.	Paralyzed.

When this occurs, further obstruction then develops from the presence of the increased amount of mucus secreted by these congested surfaces; and beyond this, again, the presence of mucus in the upper air-passages often causes some degree of laryngeal spasm, after which complete occlusion of the airway is very soon an accomplished fact.

In this manner it is frequently the case that true anoxæmia, evidenced only by slightly faster and deeper breathing, with a slight wheeze or mucous crepitation during inspiration, and slight duskiness of the ears, arises under an anæsthetic, but, unfortunately, passes unnoticed until one of the grosser forms of the asphyxial factor is added for a few seconds, either by posture, by the operation, or by reflex closure of the glottis. At this juncture respiration ceases suddenly, the dilated heart fails immediately, and "a death from syncope" is reported, which is, in fact, nothing else than a death from an increasing anoxæmic element, which it should have been the administrator's first duty to discover and prevent.

CHAPTER V

THE SIGNS OF ANÆSTHESIA

RESPIRATION.—The regularity and efficiency of this automatic function is the most important evidence of perfect anæsthesia.

Though regular, respiration may be (*a*) too deep and laboured, showing that the respiratory centre is engorged with venous blood, because some obstructive factor is present in the lungs or air-passages; or (*b*) too shallow, due to anæmia of the respiratory centre from partial failure of the circulation in the brain, or over-dosage.

Though efficient in depth, respiration may be—(1) Irregular, from (*a*) intermittent action of the medullary centre, as in cerebral tumour and abscess; or from (*b*) intermittent mechanical and reflex causes, such as obstruction of the airway by falling back of the tongue; (*c*) old pleuritic adhesions; (*d*) reflex laryngeal spasm from surgical stimuli; or (*e*) hampered descent of the diaphragm. (2) Too rapid, usually from imperfect narcosis and mental emotion, sometimes in pyrexia, and more rarely in deep anæsthesia with some anoxæmic factor. (3) Too slow, a very rare condition, except in extreme over-dosage, *i.e.*, poisoning of the respiratory centre; pressure of cerebral tumour hæmorrhage, or abscess; and still rarer in cases of idiosyncrasy, where very slow respiration is normal to the patient in health. Cheyne-Stokes respiration also is sometimes observed in asthenic patients.

THE CORNEAL UPPER EYELID REFLEX.—The most reliable sign of the exact degree of anæsthesia present at any given moment is afforded by the reflex activity of the upper eyelid in response to a touch upon the centre of the cornea. This *reflex* closure of the upper eyelid gradually diminishes in activity as anæsthesia becomes more profound, and disappears entirely at the end of the third or surgical degree of narcosis. In order to elicit this sign with accuracy, the corneæ of both eyes and the edges of the upper lids should be tested, when required, in the following way:

Standing above or behind the patient, the pulp or palmar surface of the middle finger only of one hand should be gently inserted between the closed eyelids, and made to draw the upper lid open as far as to disclose two-thirds of the cornea. Whilst doing this that finger-pulp very gently but definitely brushes against the surface of the cornea, passing first over its exact centre, and then against the palpebral edge of the upper eyelid in one movement, which ends with the sudden letting go of the lid from the finger. The degree of activity with which the upper eyelid then closes constitutes the most invariable evidence of the extent to which the muscular and nervous systems are at that moment paralyzed by the anæsthetic.

If the corneal lid reflex be very active, more anæsthetic must be given to weaken it. If it be very weak, the anæsthetic must be withheld until it becomes more active, thus nicely balancing the surgical stage of anæsthesia throughout, by maintaining this reflex at the point of weakly active response.

This test in deep stages of anæsthesia is one of extreme delicacy, and upon the accurate observation of its even

feeble presence depends the complete assurance of the administrator that he has not ventured too far in the narcosis of the cerebral centres. There is always some variation in the activity of the right and left upper eyelids respectively, and it is proper to be guided by the more active one of the two, upon the assumption that a local cause is responsible for the lack of excitability in the other.

As will be seen elsewhere in this treatise, the third or surgical degree of anæsthesia is characterized by the maintenance of a " weakly active " corneal lid reflex, and is limited by its disappearance. It is therefore extremely important that the administrator should train himself to elicit it frequently with gentleness and accuracy, and to rely upon it as his best guide to the depth of anæsthesia.

The common mistake is often made of holding open the eyelid with one finger, and then touching the cornea with another finger. As the upper eyelid cannot then move at all, and the lower eyelid does not and is not intended to cover the cornea at any time, no reflex takes place, and no information whatever is afforded by the ceremony.

THE PUPIL.—The size of the pupil of the eye in the different degrees of anæsthesia is subject to variation from so many causes that the simple observation of its diameter at any given moment is insufficient evidence of the existing depth of narcosis.

As a broad rule, the deeper the anæsthesia, the larger the pupil becomes; but imperfect oxygenation of the blood, surgical shock, and hæmorrhage, increase the dilatation in deep anæsthesia, whilst in moderate degrees of anæsthesia surgical stimuli and impending vomiting produce the same effect.

It has been usual to describe a primary dilatation of the pupil during the induction of anæsthesia, a condition of moderate contraction in the surgical degree, and a second dilatation in profound narcosis, and this, no doubt, would be the case were no surgical operation to be in progress; but, as pointed out above, the distinction between the stages of light anæsthesia and profound narcosis, in both of which a dilated pupil may occur, rests upon the presence or absence of the corneal lid reflex at the moment of observation, and it is therefore of vital importance to make certain of this latter fact, which invariably and definitely fixes the safety limit of narcosis, rather than to place confidence in the condition of the pupil alone.

Dilatation of the pupil should be taken as a hint to immediately test the corneal lid reflex in both eyes, and it is proper to be guided entirely by its result.

The effect of the sudden exposure of the pupil in a good light is to cause its contraction. This mobility is abolished when the paralytic dilatation of profound narcosis has taken place, usually a little later than the complete disappearance of the corneal lid reflex.

THE COLOUR OF THE SKIN in anæsthesia is a mirror of the blood circulating beneath it. The face, including the lips, nose, and ears, affords the most convincing evidence of efficient circulation when its natural colour is preserved or a rosy flushing of the surface is maintained; on the other hand, the slightest tendency to a bluish tinge of the lips, ears, cheeks, or finger-tips, denotes that an insufficient supply of air is gaining entrance to the blood; whilst a tendency to pallor of these parts, and also especially of the nose and along the line of the facial artery and its branches from the mandible towards

the nose, indicates quite certainly a commencing failure of the force of circulation and strength of cardiac systole.

Pallor in light anæsthesia may be due to impending sickness, occasionally to surgical shock or hæmorrhage; in deep anæsthesia, to over-dosage, bad posture, or exhaustion from shock.

PULSE.—The normal radial pulse as a rule becomes fuller and stronger with the onset of anæsthesia, and when this is established its rate largely depends upon the particular anæsthetic employed. It falls to 68 or 64 or less per minute under chloroform and ethyl chloride, rises to 86 or 90 under ether, and is often more frequent than this under nitrous oxide unmixed with oxygen. The presence of anoxæmia always tends to raise the pulse-rate.

Intermission and irregularity of beat are signs of grave significance, showing impending failure of the circulation, and under chloroform may be valuable signs of a too profound narcosis.

Increasing rapidity or a tendency to a running pulse apart from anoxæmia indicates impending exhaustion, most frequently due to surgical shock, if the heart be free from disease.

Slowness of the pulse is a remarkable characteristic of certain families and individuals. Many men of great intellectual force and hereditary longevity exhibit a pulse of 60 to 64 per minute as a permanent rhythm, which is not readily disturbed by either emotion or exertion. Apart from these individuals, whose pulses are slow before induction, in anæsthesia a slowness of the pulse is only observed under chloroform and ethyl chloride, which both lower the general blood-pressure, and, if the rate fall befow 56, usually implies an impending failure of the circulation.

The temporal pulse is an excellent guide to the anæsthetist, being easily palpable both as it emerges on the surface anterior to the attachment of the ear, and also as it passes over the temporal and frontal bones beneath the skin of the forehead. The superior coronary pulse, which is to be felt about $\frac{1}{3}$ inch from the margin of the upper lip, upon its mucous surface, is also of use for occasional reference.

THE MUSCULAR SYSTEM.—The voluntary muscles pass through various phases of excitation before the attainment of paralysis and flaccidity in the surgical degree of anæsthesia. Voluntary struggling, involuntary struggling during the excitement stage, tremor, clonus, and rigidity of the muscles, are all observed in imperfect narcosis, and are more marked the longer the induction period is allowed to continue. Nitrous oxide as a rule causes no excitement period, and ether anæsthesia induced with its aid should therefore be free from struggling.

Limitation of air-supply, whether extrinsic or intrinsic to the patient's system, is frequently accompanied by muscular rigidity.

General tremor is seen most frequently under ether in the lighter stages, and is accentuated by cold and exposure. Clonus arises when a limb is allowed to rest in a posture causing passive tension of the flexor muscles, and can be abolished by correcting this posture.

Rigidity of the abdominal muscles is sometimes persistent after the attainment of the third stage of anæsthesia without cyanosis, and it is in these cases that the deepest narcosis may be permitted. It should, however, not be forgotten that the recti abdominalis are on the stretch when the patient is supine; that, apart from

anæsthesia, it is usual to flex the legs to obtain abdominal relaxation; and that, in certain patients whose chest walls are inelastic, the recti work constantly as definite muscles of expiration, and cannot be relaxed with safety. If the head has been somewhat extended upon the trunk, a slight raising of the shoulders and flexion of the neck will often assist in rendering the abdomen less taut.

SURFACE TEMPERATURE.—The body temperature invariably falls during the inhalation of an anæsthetic, and this is probably more marked in the case of ether and its mixtures, on account of the flushing of the skin which it induces. Patients, however, whose hands and feet were cold before induction almost invariably regain the natural warmth of the extremities in the early stages of anæsthesia, if properly clothed with stockings and covered with blankets.

After this, during an operation, the warmth of the patient's forehead is an excellent indication of the general vitality. Exhaustion and shock are always evidenced by coldness of the skin of the forehead, and by a breaking out of general perspiration, first seen in this situation.

The preliminary hypodermic injection of $\frac{1}{100}$th grain of atropine sulphate one hour before the operation will, in many cases, prevent sweating under ether and thus retain the body heat, which is so valuable a factor in the economy of vitality.

CHAPTER VI

THE PHYSICAL TYPE AND TEMPERAMENT OF THE PATIENT

The preliminary examination of the patient resolves itself into two parts:

1. The recognition of the physical type to which the patient belongs, including the temperament and habits of life.

2. The discovery of abnormalities and pathological conditions within the patient's system.

The classification of patients under different physical types with regard to the inhalation of anæsthetics is no easy matter, because perfect definition is required in writing, which, it must be understood, is only approximately true in practice.

The mingling of two or more types in one subject with apparently contradictory attributes must often render this study less useful than would at first sight appear. But, nevertheless, the practised eye is guided much by the appearance of the patient in judging, not only what anæsthetic to use, but what difficulties are likely to arise, and the probable after-effects which may be anticipated.

A preliminary study of the effects of certain physical variations in individuals and their habits of life upon the conduct of general anæsthesia is necessary before arriving at a classification of the different types of patients.

SEX.—As a class males require larger quantities of anæsthetic drugs, and are less easy of management than females.

It may here be pointed out that males pass through a period of life, usually in their teens, when hysterical symptoms are quite as apt to manifest themselves as in somewhat older females. During this time the nervous system is highly excitable, and the patient apt to be suspicious of being taken unawares, held down, or roughly handled; he has a terror of pain, and is likely to be sick and faint from apprehension amid strange surroundings. The effect of fear has also a depressant action upon the blood-pressure in male adults.

The usual greater muscular development of males renders any tonic spasm or voluntary or reflex movement more inconvenient during anæsthesia, on account of its greater power and duration than in females.

The presence of a beard prevents the necessary close fitting of face-pieces in some male subjects, and the habit of over-indulgence in alcohol renders the system unusually resistant to the effects of ordinary doses of anæsthetics; whilst excessive tobacco-smoking causes the pharynx and respiratory passages to be more irritable to the presence of their vapours.

Chloroform is less safe *ab initio* in well-built young males than in females on account of the asphyxial factor introduced by their more powerful holding of the breath, muscular movements, and spasms in the second stage of anæsthesia.

There are females who approach the masculine type in build and muscular development, and require the same dosage as males.

AGE.—Children might be looked upon as adults of small size from the point of view of anæsthetic dosage by bulk or weight alone; but they differ from adults in important respects both in nervous development and reserve strength.

The administrator soon finds that very small and young children are apt to exhibit marked and inconvenient muscular movements in the surgical degree of anæsthesia, which older children do not show.

Anæsthetics when inhaled first affect the higher cerebral centres of ideation and volition, and require a greater length of time and dosage to reach those centres which are secondary and lower in the nervous scale.

By the development of connections between the nerve cells, and from the training of the will and intellect, lower centres are gradually brought into control by the higher ones as life advances, until in response to ordinary stimuli the lower do not act alone. In those subjects, therefore, whose intellect and will are most developed, complete narcosis is most easily accomplished; whilst in those whose co-ordination of the higher and lower centres is less perfect, such as young children, persons of weak intellect, and the subjects of mental disease, narcosis of the secondary centres may be delayed, and if operations be commenced before its attainment, the presence of muscular reflexes still active becomes apparent. This forms the explanation of the unsatisfactory anæsthesia yielded by the weaker anæsthetics, such as nitrous oxide and "whiffs" of ether in children and mental patients.

Young children are particularly easily depressed by air limitation, and secondary syncope readily ensues

upon a moderate degree of anoxæmia, which must therefore be relieved immediately if it should arise.

Children are highly susceptible to surgical shock, the prolongation of certain operations which would be of little moment in the case of adults often depressing their vitality to an unusual degree. This condition is most frequently noticeable under chloroform when pallor, faintness, feeble respiration, and sweating of the forehead and trunk, quite apart from over-dosage, may appear with very little warning. The encouragement of deeper breathing by lip-rubbing, and the addition of ether to the chloroform, frequently effect an improvement. Nevertheless, the duration of operations upon young children should always be as brief as possible, on this account.

These remarks upon the production of shock apply equally well to both extremes of age. Old people and those who are past middle age must be treated, if anything, with greater care and caution than the very young, because impairment of thoracic expansion and commencing degeneration of all parts of the system turn the balance against them in recovery from conditions of collapse.

Chloroform is usually very well borne by patients past the prime of life, and, as it has no tendency to irritate the lungs and air-passages, nor to make excessive demands upon the activity of the respiration and circulation, may be used in preference to other anæsthetics in persons over sixty years of age.

Very aged patients should not be starved for more than three hours, and may also be given a little brandy and water a quarter of an hour before an anæsthetic.

Warmth of the body promoted by ample clothing,

and a temperature of 70° F. in the operating-room, should be especially maintained, and the operation itself reduced to the shortest possible duration in aged patients.

Regarded from the point of view of age alone, the C_2E_3 mixture is the most suitable anæsthetic for babies and children up to twelve or fourteen years of age, ether (aided by nitrous oxide or ethyl chloride for the induction stage) from fourteen to sixty years, and chloroform from sixty years onward.

TEMPERAMENT.—Patients of placid and lethargic temperament require a less quantity of anæsthetic, and are not so liable to excitement, laughter, garrulity, or involuntary movement, in the first and second stages of anæsthesia and during recovery, as those of hysterical, neurotic, and highly strung disposition.

Persons of the latter constitution often require considerable tact in inducing them to allow a face-piece to be applied, or in encouraging them to continue inhalation of chloroform until unconsciousness is attained.

The author's experience in the case of patients who express a horror of "having something put over the face" is that many such people are mouth-breathers, and having already an instinctive perception of their nasal deficiency, or perhaps some experience of asthmatic attacks, dread the feeling of suffocation which air limitation always brings them. A small mouth-prop inserted between the molar teeth before the inhalation commences, and instructions to breathe entirely through the mouth, will often reassure them.

Some nervous persons, on the other hand, may attempt to retch on the insertion of a moderate-sized mouth-prop when seated in a dental chair. In many cases this may also be due to a mechanical cause, for it

will be found that, with the mouth widely open and head slightly thrown back, the base of the tongue and the tonsils are apt to touch the pharynx, and it is this contact which starts the act of retching.

In many children and thick-necked adults the tonsils are also chronically enlarged, and in them not only may retching very readily be caused by opening the mouth wide, but it may arise at any subsequent moment of nitrous oxide anæsthesia from the same cause. Profuse secretion of saliva and mucus may act in the same way, and the remedy for these difficulties is to sit the patient quite upright in the chair, with the head bent slightly forward, so that the tonsils do not touch the pharynx and saliva cannot flow into the throat.

If the same tendency to retching occur when the patient is lying down, before taking the anæsthetic for a surgical operation, he should be turned on his side with the face somewhat towards the couch, for the same purpose.

Neurotic patients are more apt to display muscular tremors, rigidity, and reflex movements, during anæsthesia; and screaming, shouting, and gesticulation, as well as prolonged sickness, are commoner in them during recovery than in people of normal temperament.

SIZE AND BUILD.—There is a decided increase in the quantity of anæsthetic inhaled by patients of unusual size and weight, and throughout the scale the amount required is in direct proportion to the patient's bulk.

Many anæsthetic inhalers are too small in their internal calibre for inducing narcosis in patients of powerful build without producing some degree of mechanical asphyxia after the lapse of a few minutes' application,

and these should be discarded after careful trial by the anæsthetist.

MUSCULAR CONDITION AND DEVELOPMENT.—As would be expected, persons of sedentary and inactive habits do not display the same tendency to muscular phenomena as those who lead a more athletic life. The greatest difficulties in the production of complete flaccidity are to be met with in hunting and military men, athletes, and those whose work is manual and arduous.

In these patients, though chloroform is often of great value in the production of tranquillity, it is less safe than ether in the early stages, and even when resorted to subsequently, for it will be found sometimes that under chloroform the musculature requires a dose that the circulation cannot stand. Pallor and a very slow pulse will indicate that flaccidity has only been attained at considerable risk of over-dosage.

COMPLEXION AND COLOUR.—Persons of florid colour require as a rule more anæsthetic, and more readily show cyanosis, than those of pale and sallow complexion; whilst dark-haired individuals and those disposed to bilious attacks tend, perhaps, to be more sick after the administration than the fair-haired, though the latter are by no means immune from after-effects.

VOICE AND SPEECH, though they are to be considered more particularly later in connection with diseases of the throat and respiratory organs, lend some aid in the estimation of the patient's mental activity and general state of health. Rapid talkers as a rule are rapid thinkers, whose active questionings require alertness in response, and, as in many instances they are also

highly nervous, calmness and tact in the administration are more than ever needful during the induction of anæsthesia.

It is a golden rule never to anæsthetize a patient without first speaking to him and eliciting a verbal reply, the manner of his answer and tone of voice demonstrating more clearly whether he is in good spirits, and the nature of his apprehensions, than any other method. Huskiness of voice or aphonia must, of course, be instantly inquired into, with the view of possible obstruction in the air-passages.

CHAPTER VII

PATHOLOGICAL CONDITIONS OF THE PATIENT AND THE CHOICE OF THE ANÆSTHETIC

There can be no finer training for the physician nor a more interesting study in clinical medicine than the rapid diagnosis of those disorders and diseases which affect the exhibition of anæsthetics, and the immediate application of the gas or vapour as a test of its value.

The simplest illustration of this statement occurs in the detection of emphysema.

A patient whose thorax is barrel-shaped, with a wide subcostal angle and limited chest expansion, will suffer from asphyxial symptoms under the influence of comparatively slight air limitation—*i.e.*, will become deeply cyanosed under nitrous oxide and air, and also under ether with a bag inhaler. The preliminary recognition of the condition of emphysema will prevent the selection of these anæsthetics for such a case, and will explain the cyanosis which may even arise when nitrous oxide is administered with a considerable percentage of oxygen, or when chloroform is exhibited upon an open mask.

The extent of the physical examination of the patient before the administration of an anæsthetic should be in inverse proportion to the administrator's experience; but it cannot be expected that the novice will be able to profit fully by the knowledge of the patient's system

thus gained until he has mastered the use of his anæsthetic apparatus and the technique of dosage.

The probable effects, in anæsthesia, of the presence of various pathological states and conditions will now be described; but it must be remembered that the most important are those which affect the entry, absorption, and elimination, of air.

The immediate question in a case of empyema, for instance, will not be, "What is the patient's temperature and the condition of the tongue?" but, "How far is he already cyanosed, and what area of lung tissue is actually working?"

THE UPPER AIR-PASSAGES.—The open mouth must always be examined to insure the absence of artificial dentures and loose teeth, tumours, or foreign bodies, and for the purpose of noting any gap between the teeth where a mouth-gag may be inserted in the event of jaw spasm arising when no mouth-prop has been used.

Patients whose jaws are *edentulous* may often give trouble in anæsthesia, because the lips flap together, and the tongue impinges upon the palate during inspiration unless the jaws be separated by the finger, gag, or large dental mouth-prop.

THE TONSILS should also be looked at with the aid of a spatula if any suspicion of their enlargement has arisen from the sound of the voice or fulness of the throat on external inspection. Children of cherubic appearance and all thick-necked subjects are very prone to suffer from this condition, which may greatly interfere with anæsthesia.

A large flabby tongue should be noted, as it may

impinge upon the pharynx or block the entrance to the larynx, and require subsequently to be drawn forward.

Should the appearance of the patient suggest that nasal breathing is imperfect, this should be tested by telling him to close the mouth and to breathe through the nose while one nostril at a time is closed with the finger.

No attempt should be made to anæsthetize a patient, who cannot breathe adequately through the nose, without the insertion of a small prop between the teeth.

A chronic discharge of muco-pus from the nose may cause continual swallowing and cough during anæsthesia by trickling backward into the pharynx, but can only be arrested by proper nasal douching before the induction, which is in many cases out of the question.

A RETROPHARYNGEAL ABSCESS is in such a dangerous position for invasion of the larynx with pus, if it should suddenly burst, and the tissues surrounding the superior aperture of the larynx are so liable to be already œdematous, that the author is of opinion that such cases ought not to be given a general anæsthetic at all. But if this be attempted, chloroform administered to a very light surgical degree, with the patient in Trendelenburg's position and semi-prone, would be the safest anæsthetic and posture to adopt.

CELLULITIS OF THE NECK also requires the administrator's very serious consideration before deciding to give an anæsthetic, because œdema of the tissues enclosing the larynx and trachea is exceedingly likely to increase during anæsthesia, and result in asphyxia.

If the external swelling would render tracheotomy impossible, no anæsthetic must be given; but if the abscess be entirely at the side, and swelling does not cause respiratory distress, a very light chloroform anæsthesia may be permitted. Nitrous oxide, ethyl chloride, and ether, are absolutely contra-indicated.

The danger of moderate respiratory obstruction becoming acute in anæsthesia is much enhanced when the swelling causing pressure upon the air-passages is inflammatory in nature, but solid growths and enlarged glands of chronic development also swell rapidly under the influence of moderate congestion.

GOITRES often displace the trachea laterally, and occasionally cause absorption of the cartilaginous rings of the trachea, so that either extension or rotation of the head or manual pressure or traction by the surgeon may suddenly occlude the airway during narcosis. The employment of atropine and open ether is well suited to these patients.

TUMOURS OF THE EPIGLOTTIS AND LARYNGEAL GROWTHS are so obvious a source of asphyxial danger during their removal that preliminary tracheotomy is always advisable, the only exception to this rule being in the case of small papillomata within the larynx, which, in the author's experience, are unlikely either to swell or bleed under chloroform.

The presence of a surgeon anticipating the need and prepared to perform tracheotomy if obstruction to breathing should arise above the trachea, justifies the anæsthetist in attempting a gentle induction of chloroform anæsthesia in far more obstructed patients than would otherwise be the case; but extension of the lower

jaw by drawing open the larynx will sometimes avoid the expected necessity. Diphtheritic laryngitis is an example of these circumstances.

Pressure upon the trachea or bronchi caused by **enlargement of the mediastinal glands,** a malignant growth or aneurismal sac within the thorax, renders the exhibition of any anæsthetic extremely hazardous, because impending asphyxia cannot be relieved by tracheotomy.

IMPERFECT EXPANSION OF THE CHEST WALLS from any cause produces asphyxial symptoms in anæsthesia of a characteristic nature.

Having lost the aid of the thoracic bellows, respiration in this condition is carried on by the diaphragm producing inspiration, and the abdominal muscles acting as an expiratory force, resulting in a pulmonary aeration which is below normal, but sufficient to maintain life. This is, however, unequal to abnormal demands, as will be seen by dyspnœa ensuing upon slight exertion, and is shown in anæsthesia to proceed from the slowness of the respiratory gaseous interchange.

Instead of the free **ventilation** of the pulmonary alveoli by **convection** of the air, which occurs when the healthy chest wall rises and falls, the rigid chest, even by the best efforts of the diaphragm and abdominal muscles, only enables aeration in the deeper bronchi to take place by **diffusion** of the gases, which is a much slower process, the effect produced in anæsthesia being a primary apparent resistance to the dose of anæsthetic inhaled (due to its retarded absorption), and then a somewhat sudden deep narcosis (due to retarded elimination from the lungs).

Abdominal breathing is efficient only up to a certain

point, but perhaps not more than half as efficient as thoracic expansion for aeration under slightly abnormal conditions. The thoracic muscles are an intrinsic part of the mechanism belonging to the respiratory centre which work with the diaphragm from birth, whilst the abdominal muscles are voluntarily called into play to prevent anoxæmia during disease or senile decay; and as they may become paralyzed earlier than the thoracic muscles by the anæsthetic, the importance of normal chest expansion to the anæsthetist becomes evident.

CHRONIC BRONCHITIS AND EMPHYSEMA render the patient very intolerant of ether, excessive secretion of mucus, cough, and cyanosis, early resulting from its employment. Chloroform is indicated in its stead, unless the heart be very weak, when the C_2E_3 mixture should be substituted for it. Nitrous oxide produces an unsatisfactory anæsthesia in these cases unless mixed with oxygen, when a fairly normal result may be expected.

The author has on several occasions administered a little ether to patients recovering from acute bronchitis when lying in bed in a warm room, with the fortunate result that catarrh, cough, and mucous secretion, have at once disappeared; but this must not be taken as indicating ether for a long operation in such cases, nor for hospital out-patients who have to return home afterwards.

PHTHISIS, whether active or latent, presents, as a rule, a slight degree of bronchitis, a diminished area of working lung tissue, and a possibility of hæmorrhage from the focus of disease. The air-passages must, therefore, not be irritated, nor must the circulation be

excited. Chloroform will suit phthisical patients best in the operating-theatre, and nitrous oxide and oxygen in the dental chair.

Very careful sterilization of inhalers must be practised after their use for cases of pulmonary tuberculosis.

EMPYEMA.—Two facts of extreme importance must be ascertained in this condition before attempting to induce anæsthesia: (1) whether there is a communication between the abscess cavity and a bronchus, for in that case expectoration of pus will be a symptom, and the possible entrance of fluid into the trachea during anæsthesia a danger to be guarded against; and (2) whether the heart is pressed upon or displaced by the fluid collected in the pleural cavity. If the pus be situated in the left side, cardiac displacement and hampered action is often a marked symptom, producing a tendency to syncope in anæsthesia both during induction and when tension is relieved as the heart returns to its normal position. A collection of pus on the right side produces a less marked effect upon the heart.

If the relief of empyema be undertaken during the course of pneumonia, general anæsthesia should not be induced unless the equivalent of one lung is free from pressure or inflammation. Oxygen may be administered with the anæsthetic, which should be chloroform or the C_2E_3 mixture, if there be any cyanosis, and only a very light anæsthesia maintained.

The cardinal principle in cases of empyema is **to keep the sound side uppermost,** to allow of its full respiratory expansion; and, in case the abscess burst into a bronchus, to save the healthy lung from invasion and the patient from drowning in the escaping fluid.

FIG. 1.—THE KINGSTON FOWLER POSITION FOR OPERATING UPON LUNG ABSCESS OR EMPYEMA.

This prevents fluid from entering the bronchus of the sound lung by keeping the diseased side lowermost throughout the anæsthesia.

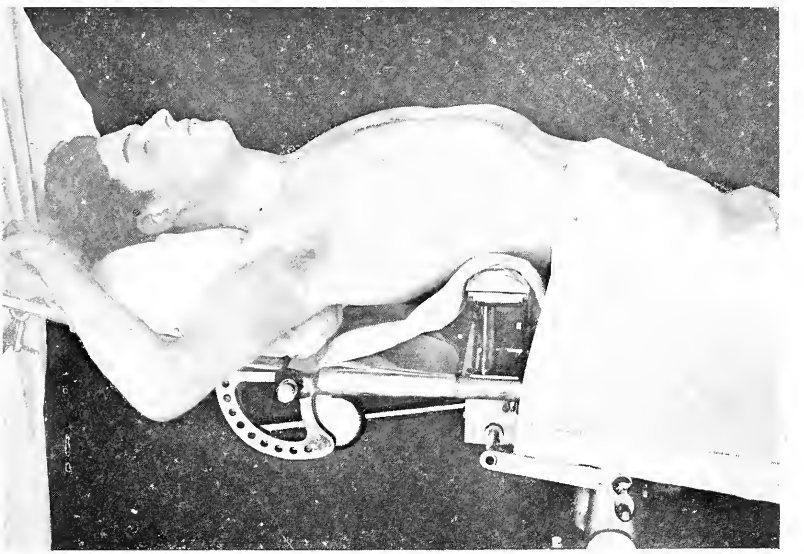

FIG. 2.—WARING'S SUPPORT FOR ELEVATING THE LOINS DURING RENAL AND GALL-STONE OPERATIONS.

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Such a catastrophe has happened without this precaution, within the author's knowledge.

The presence of old pleuritic adhesions is often unsuspected, but usually limits normal chest expansion to some extent, and introduces a mechanical impediment to regular breathing which is not sufficiently recognized.

Many patients who breathe jerkily under nitrous oxide and oxygen, and those who tend to cease breathing from time to time under chloroform, are the subjects of these adhesions, and require special care to avert an element of anoxæmia in anæsthesia.

Tight corsets or belts restricting the full expansion of the chest cause symptoms exactly resembling those just described.

Distension of the abdomen by ascitic fluid or ovarian and other tumours may impede the descent of the diaphragm in such a manner that only light anæsthesia is permissible. Many such patients are orthopnœic, and should not be laid down flat for the induction of anæsthesia, but should be propped up until the abdominal distension has been relieved during the course of the operation.

THE HEART AND CIRCULATION.—Both radial pulses should be felt, and any difference in their size and strength of beat noted for use during the operation. A slow pulse or occasional intermission of the beat may suggest a fatty heart; but any irregularity of force and rhythm is of more importance, as showing a decidedly impaired circulation at the time.

The pulse-rate before taking an anæsthetic is often quick, and the face pale from fear; but it will be found that a few reassuring words will improve a patient's

colour during the preliminary examination. A slower and steadier pulse and brighter colour also supervene directly unconsciousness is attained.

If the heart's apex-beat be in the normal situation, and its rhythm regular, there will be no reason to anticipate circulatory trouble in anæsthesia, and this applies also to cases which are known to have some cardiac lesion.

The stethoscope should be used in every case before inducing general anæsthesia, for it is always reassuring to the patient to be definitely told that there is no reason why he should not take the anæsthetic well, and because bystanders are then witnesses that the heart has been examined.

Valvular diseases must be diagnosed by the usual methods as accurately as possible, a few questions as to shortness of breath on slight exertion and previous fainting attacks proving valuable guides in the estimation of the extent of the disease and its nature.

Broadly speaking, mitral incompetence will tend to the production of anoxæmic symptoms in anæsthesia, and aortic incompetence to syncope and respiratory failure from cerebral anæmia. The latter lesion involves a far more serious responsibility to the administrator than the former.

The nitrous oxide and the oxygen mixture will be safest in the dental chair, and the C_2E_3 mixture for surgical operations. Ether upon the open mask is in some cases advisable.

Extreme care must be taken in cardiac valvular disease that no asphyxial element is allowed to arise or persist, and for this reason closed methods—*i.e.*, nitrous oxide alone or ether or ethyl chloride with bag inhalers

—must not be employed. Pericardial adhesions with hypertrophy would greatly enhance the dangers of anæsthesia; but the same anæsthetics would be advisable as in valvular diseases.

In obese and elderly subjects with a somewhat "flapping" pulse and distant heart-sounds, chloroform alone is not so well borne as the C_2E_3 mixture, and ether is sometimes an excellent adjuvant for stimulating the feeble action of the fatty heart.

The existence of cardiac disease or degeneration need not endanger life in anæsthesia on account of the pure action of a suitable anæsthetic, but does so from the fact that any intercurrent anoxæmic strain or surgical shock may turn the balance against the patient, and lead to syncope. Impairment or arrest of respiration is, therefore, the most depressing factor to be feared, and the performance of formidable or prolonged operations upon such subjects is to be deprecated.

VASCULAR DISEASES.—For patients with hard and tortuous arteries, indicating the presence of atheromatous degeneration, chloroform should be chosen with the view of avoiding a marked rise of blood-pressure, and care must be taken to eliminate anoxæmia for the same reason. Cerebral hæmorrhage has been recorded from the administration of ether in these cases, and may be precipitated in patients who have had a previous attack of apoplexy by such a stimulant. The existence of an aneurism also suggests the same measures and precautions, but if it be intrathoracic should indicate a special examination to estimate the amount of pressure exerted upon the heart and lungs, before deciding whether a general anæsthetic ought to be administered at all.

The presence of **a clot** which may easily become dislodged during **venous thrombosis,** is a definite danger in anæsthesia. Two fatalities which have been clearly traced to this cause by Dr. Probyn-Williams, and one by Mr. Clapham, have been reported.[1] Cardiac embolism occurred in the first case from the displacement of a clot from the left internal iliac vein in a patient aged thirty-three, whilst under ether for the removal of the breast.

In the second case an ante-mortem clot was discovered in the right ventricle of a woman aged fifty-two, who died in transit from the operating-theatre after operation under chloroform for a parotid abscess, but the seat of thrombosis was not discovered.

In the third case a boy aged ten died under chloroform during a mastoid operation, in whom a clot of the same character was found in the pulmonary artery, which had probably been displaced from the lateral sinus.

PYREXIA distinctly influences the intake and elimination of anæsthetics, rendering the gas or vapour less soluble in the blood as the body temperature rises, and, owing to the unusual rapidity of circulation and respiration, also increases the rate of elimination from the lungs. Pyrexial patients appear, therefore, somewhat resistant at first to the effects of any anæsthetic; but as their central nervous system has been overstimulated by circulating toxins, so the point at which narcosis ensues is not long delayed, because early exhaustion of the centres from further stimulation aids the action of the anæsthetic. On the whole, the presence of a moderate degree of pyrexia helps to maintain a satisfactory circulation and ample respiration in anæs-

[1] Transactions of the Society of Anæsthetists, vol. iv., p. 36.

thesia, but the appearance of a primary resistant effect in the early stages is apt to deceive the administrator into temporary over-dosage. Like alcoholics, pyrexial cases recover rapidly, and are rarely sick afterwards, excepting those suffering from septic infection.

Patients who have lived in the tropics and suffered from **malarial fevers** exhibit a very marked resistance to ordinary doses of anæsthetics, and, in fact, closely resemble alcoholics in this respect.

That this resistance is not due only to past indulgence in alcohol is proved by the exhibition of exactly similar symptoms by females and total abstainers who have had malarial fever. In order to attain tranquillity in these subjects, nearly twice the ordinary dose of the major anæsthetics is often needed, while nitrous oxide by any method yields only a few seconds' anæsthesia.

Whether this state of resistance is primarily due to an altered condition of the nervous system persisting for some years after the attack of malaria, or to the actual presence of toxins in the blood, which prevent the absorption of the anæsthetic, is not quite clear; but the latter explanation is possible considering the fact that recurrent attacks of malaria take place long after removal from the sources of infection.

EXHAUSTED AND COLLAPSED PATIENTS require comparatively small quantities of anæsthetics to produce tranquillity; chloroform tends to lower the blood-pressure, so that ether by the open method is to be recommended in such cases.

Cases suffering from **INTESTINAL OBSTRUCTION** require the utmost care and foresight in the conduct of anæsthesia.

The toxic state which early supervenes renders all

their reflexes extremely dull in action, and when the tendency to regurgitation of intestinal contents by the mouth is considered, the danger of inhalation of the vomited matter into the larynx is seen to be increased. In these, again, the C_2E_3 mixture will be the best choice.

THE NERVOUS SYSTEM.—In normal health, as tested by the influence of anæsthetics, there is considerable difference in the vitality of the respiratory centre itself. Individuals who breathe very slowly are met with among those who are slow of speech and action, and in these, although no pathological disorder could even be surmised, the author has known a tendency to a gradual fading away of respiratory movement with quite moderate doses of any anæsthetic. This phenomenon should not awaken surprise when the numerous variations in activity of all the other faculties and senses in individuals is once appreciated; but the only important point is that the administrator's preliminary observation should tell him that his patient may belong to this variety.

Any circumstance which increases **INTRACRANIAL TENSION** may bring about a similar but more marked effect, by causing pressure upon the medulla oblongata, the presence of a cerebral abscess affording the best demonstration of this fact.

The patient may be semi-conscious and breathing lightly; but after a few minutes' inhalation of pure chloroform, which is the only suitable anæsthetic, respiration may cease completely, owing to the slight initial rise in general blood-pressure elevating intracranial pressure to the point of central respiratory paralysis. Now artificial respiration is begun and

steadily maintained until the abscess is opened by the operator, when, relieved from pressure, the medullary centre resumes its function and natural respiration recommences.

Instances also occur during later stages of the operation for cerebral tumours, abscesses, and depressed fractures of the skull, when the operative measures themselves may produce the increased intracranial tension, in some cases mere rotation of the patient's head to a new position sufficing to alter the pressure and depress the central respiratory mechanism.

No anæsthetic is required *ab initio* for patients who are unconscious from disease, and none must be administered during artificial respiration; but it is possible that a little chloroform might be required during the operation in such cases if consciousness should return after the relief of tension.

Particular attention must be paid to the respiration of patients with paraplegia, for, localized and distant as the lesion may seem to be, the author's experience shows that disseminated spots of sclerosis in the brain and medulla are not uncommon in such patients; and though a previous diagnosis of lateral sclerosis, tabes dorsalis, or disseminated sclerosis, may have been made, this forms no guarantee that the medulla is unimpaired, and that hesitation, undue slowness, and fading away of the respiration, will not manifest themselves in anæsthesia.

EPILEPTICS may be anæsthetized in the same manner as other patients, according to their type and build. They are often of distinctly neurotic temperament, and apt to struggle unduly in passing into narcosis, while wide dilatation of the pupil is common in all

stages of anæsthesia, and cannot be relied upon as evidence of a definite degree of narcosis.

There are records of epileptics who have had an attack or "fit" during anæsthesia. The author has not seen this occur, but in the case of a male aged twenty-five, who was subject to epileptic fits commencing with a musculart witching of the left shoulder, during the administration of the C_2E_3 mixture, this symptom appeared in a mild form both during induction and recovery, without any other signs of epilepsy in complete anæsthesia or as an after-effect.

There is a distinct tendency to clonus and jactitation in epileptics, which must be borne in mind when giving unmixed nitrous oxide.

As clenching of the teeth might form an impediment to the progress of anæsthesia, a mouth-prop should always be inserted before commencing the administration in such patients.

Persons with a family history of **INSANITY** may be exceedingly excitable under anæsthetics, some of the most resistant and unmanageable cases in the author's experience having belonged to this class. In those who have actually passed through periods of insanity, anæsthetics are likely to determine another attack; but insane patients who are not violent may be carefully anæsthetized upon the principles laid down, according to their type and pathological condition.

Chloroform should be the main anæsthetic, because less exciting during recovery than ether; but the induction is best attained rapidly with gas and ether, and the chloroform then substituted for it.

RENAL DISEASE.—Drs. Buxton and Levy, in a paper upon "The Effects of Inhalation of Certain

Anæsthetics upon the Kidneys,"[1] stated that no deleterious effects of etherization in respect of albumin occurred in 94·6 per cent. of their experiments upon the human subject; but in 5·4 per cent. a trace of albumin was found, which rapidly disappeared.

The quantity of urine secreted was increased in light or transient anæsthesia, but diminished by long and profound narcosis. This was also found to be the case with chloroform.

Dr. W. H. Thomson,[2] from extensive experiments upon dogs, agrees with these results, but adds that with both anæsthetics the after-effect, attaining its maximum three hours after the removal of the anæsthetic, is a large increase in the quantity of urine passed.

Both ether and chloroform narcosis present a general but not accurate correspondence between urine outflow, kidney volume, and blood-pressure. Temporary albuminuria appears in dogs in a much larger proportion of experiments with ether than with chloroform.

Sir F. Hewitt[3] points out that respiratory complications are common in renal disease.

The author is of opinion that, though a short and moderately deep ether narcosis is not specially contra-indicated in patients with renal disease, with due precautions as to warmth, chloroform or the C_2E_3 mixture is to be chosen in preference, as less likely to increase existing albuminuria or give rise to bronchial and pulmonary congestion.

DIABETES.—The danger of anæsthesia passing into

[1] *British Medical Journal*, September 22, 1900, p. 883.

[2] "Anæsthetics and Renal Activity," *British Medical Journal*, March 17 and 24, 1906, pp. 608, 667.

[3] "Anæsthetics and their Administration," p. 177, 1907.

coma in diabetic patients is dependent upon the quantity of sugar present in the urine at the time of the administration.

Sir F. Hewitt, in accord with Dr. Pavy, says: "In cases 'under control,' in which sugar is at the time either absent from the urine or present only to a slight extent, general anæsthesia is unattended by risk. It is clear that special attention should be paid to the diet for some time before the administration, with the object of reducing the quantity of sugar in the circulation."[1]

The administration of an anæsthetic during **MENSTRUATION** is best avoided, on account of its tendency to increase existing neurotic disturbance and temporary malaise; but excepting these symptoms, and a possible congestion of the mucous surfaces of the body, no other reason stands in the way in cases of emergency.

During **PREGNANCY**, anæsthetics are generally taken remarkably well, provided that no asphyxial factor be allowed to complicate narcosis. Struggling, over-stimulation of the circulation, and vomiting, must be guarded against. Nitrous oxide, with plenty of oxygen, chloroform, or the C_2E_3 mixture, are the best anæsthetics for use during this period, according to the nature of the operation.

During **PARTURITION** small doses of chloroform or the C_2E_3 mixture are commonly given either with a small Skinner's mask or from a Junker apparatus fitted with a face-piece. The patient is allowed a few respirations of the vapour at the advent of each "pain." These do not quite abolish consciousness, but produce analgesia, and a slightly longer inhalation is permitted during the passage of the child's head. The third or

[1] "Anæsthetics and their Administration," p. 135.

surgical stage of anæsthesia retards uterine action, and is not employed excepting for the use of obstetric instruments.

A semi-conscious condition can be produced and maintained during childbirth by the use of repeated small doses of scopolamine and morphine. This has been practised under the name of " Twilight Sleep " by Dr. Gauss of Freiburg.[1] Beginning with a dose of ·00045 grm. scopolamine hydrobromide and ·01 grm. morphine, he found that in the case of average constitutions and susceptibility a good effect was obtained in from three-quarters of an hour to three hours. The scopolamine and morphine were used in separate solutions. If the desired effect was not then reached, a second injection of ·00015 grm. to ·0003 grm. scopolamine without morphine was given, which generally took effect in from a quarter of an hour to half an hour. A third similar dose, if consciousness had quite returned in from two to four hours, was also given. In order to ascertain the exact condition of the patient, Gauss applied a " memory test " by showing her some simple object and then asking her again after twenty minutes whether she had seen this object before. If she said " Yes," more scopolamine was given to dull the faculties still further; if she did not recollect the object, he considered that the proper degree of amnesia and analgesia had been established.

At first Gauss found that 20 per cent. of the children born were partly asphyxiated by the drugs given to the mother; but when the dosage had been as carefully as possible adjusted by means of the memory test

[1] " Archives of Gynæcology," vol. lxxviii., " Childbirth in Artificial Twilight Sleep," by Dr. Carl J. Gauss.

from time to time, the children were hardly affected at all.

LACTATION is not interfered with by the exhibition of nitrous oxide and oxygen, nor by chloroform; but the author has known the infant to refuse the breast for two days after the taking of ether by the mother, owing, perhaps, to the characteristic taste of this anæsthetic in the milk, though the quantity of the secretion was not impaired.

HABITS OF LIFE.

TOBACCO.—Patients who are addicted to excessive tobacco-smoking frequently suffer from granular pharyngitis, and exhibit an unusual irritability of the throat and air-passages to the vapour of ether. Hesitating respiration, coughing, and muscular rigidity, are more common in the early stages of anæsthesia in heavy smokers, whilst in many cases the vasomotor tone is poor, and the circulation more easily depressed than in normal health.

The muscles brought into use by the act of habitually sucking at a tobacco-pipe are strongly developed in some smokers, and may cause difficulty in light anæsthesia by their spasm or involuntary action in occluding the airways.

ALCOHOL.—Those who indulge freely in stimulants, and chronic drunkards, are unusually difficult to anæsthetize, because much larger quantities than normal are required to produce the third stage of narcosis; and unless the drug is pushed rapidly, great excitement, talking, shouting, singing, voluntary movement —often of an aggressive or pugilistic nature—struggling, rigidity, and reflex movement, appear during induction

and also on recovery. In some instances nitrous oxide alone will not produce more than momentary unconsciousness. The author has known it impossible in the worst cases to maintain anæsthesia except with chloroform vapour, so concentrated by wrapping a towel over a Skinner's mask that the same patients would have been over-dosed past the hope of resuscitation if they had not been addicted to alcoholic intemperance. Recovery is exceedingly rapid in alcoholic patients, who are often able to talk and look about them within two or three minutes of the cessation of an administration, and after-sickness is of rare occurrence.

MORPHIA.—A recent dose of morphia is a respiratory depressant. It will render the amount of anæsthetic required to attain the third degree of narcosis less than usual, and a very small quantity needful to maintain it. But in cases of morphinomania little difference of intake is noticeable when the morphia has been withheld for twenty-four hours before the operation.

CHAPTER VIII

THE PREPARATION OF THE PATIENT FOR AN ANÆSTHETIC

The physical preparation of a patient for a surgical anæsthetic is mainly directed towards the regulation of the bowels and diet in such a manner that the stomach and intestines at the time of operating shall be empty.

Vomiting may occur in the first stage of anæsthesia, from the taste of the vapour; in the second stage of anæsthesia, from irritation of the medullary vomiting centre; and after the withdrawal of the inhalation, from the same causes, and also as part of the process of elimination from the system.

The duration and violence of this vomiting are greatly minimized by the precaution of previous purgation and abstinence from food, and, in fact, vomiting during induction of anæsthesia need never occur after proper preparation of the patient, provided that the administrator steadily and firmly increases the strength of anæsthetic vapour *ab initio* to its full strength.

The purgatives most in favour for this purpose for adults are, perhaps, either two 5-grain pills of colocynth and hyoscyamus or a 1-ounce dose of castor-oil *two* nights before the day of operation, followed by an enema of soap and water or of olive-oil on the morning of the day itself.

The regulation of the diet depends on the time fixed for the operation.

The author is decidedly of opinion that *no food whatever* should be given, excepting in the most debilitated subjects, after seven o'clock the night before, for operations to be performed before 10.30 a.m. If the time fixed be between 10.30 a.m. and 1 p.m., only a cup of tea and slice of toast may be given at 7.30 a.m. If at 2 p.m., a cup of thin soup may be taken at 11 a.m. in addition to this.

For operations later in the day than 3 p.m., a light breakfast, consisting of an egg and toast or a little white fish with tea or coffee, may be ordered, and a little toast with the soup or beef-tea at eleven o'clock.

The whole anæsthesia is liable to be disturbed and far less manageable when there is food in the stomach; for, in addition to the danger of regurgitation of solid or semisolid particles into the mouth, and the blocking of the larynx at any moment during unconsciousness, straining respiration and pallor due to impending sickness are apt to arise unless an unnecessary depth of narcosis be maintained.

Rest in bed for at least a day or two before an important operation is always of value in rendering the patient accustomed to his surroundings and the routine of nursing which will afterwards be necessary, in allowing actual supervision of the meals taken, and in enforcing what is often still more necessary—*i.e.*, abstinence from excessive tobacco-smoking and from those alcoholic stimulants which are frequently taken by patients with the false idea of sustaining their strength for the ordeal.

There are many patients to whom, after loss of blood from uterine tumours, rectal growths, and other debilitating diseases, the administration of strychnia or nux vomica, in small doses three times a day for a week beforehand, is attended with much benefit by improving the vascular tone and reducing the tendency to shock during the operation.

In cases of dilated stomach, if the patient has been through the process before, or is otherwise considered to be in a fit condition, the stomach should be thoroughly washed out a few hours before the operation. If too feeble, anæsthesia may be induced and the washing out performed under its influence before incision is made.

Without this precaution several pints of fluid from the stomach may well up into the pharynx directly that organ is manipulated.

Cases of intestinal obstruction with vomiting are exceedingly dangerous to anæsthetize, for the same reason. Here lavage of the stomach is occasionally resorted to, but it is of doubtful utility, as intestinal regurgitation may still occur.

Very feeble patients may be allowed a little brandy and water half an hour before an operation, either by the mouth or rectum, according to the nature of their disease.

A draught of $\frac{1}{2}$ pint of hot water two hours before operation, repeated twice at intervals of half an hour, has been recommended for patients who are liable to suffer much from after-sickness, with the idea of diluting the anæsthetic, which is excreted by the stomach walls, further draughts of hot water being administered also

on recovery of consciousness, to wash out the gastric contents.

With regard to children, unless the mother possess remarkably strong nerve and common sense, her presence is always a decided drawback to the proper conduct of anæsthetic administration, and should be discouraged for the reason that most children are far more manageable in the hands of a kindly doctor and nurse, who are not likely to be nervous, than in those of a palpitating relation who is on the verge of tears.

It is distinctly dangerous to carry patients about from one room to another when under the influence of anæsthetics, and this should never be done before an operation if it can possibly be avoided, because (1) the blood-pressure may suddenly fall if the patient be unskilfully carried with the head raised above the plane of the body; and (2) vomiting, with possible inhalation of the vomited matter, is very likely to take place during the movement. These risks are quite unnecessary with a little management and the use of a screen in the room chosen for operation in a private house.

The use of a stretcher or wheeled couch in hospital practice has not the same objections, though the author has frequently seen obstructed breathing, coughing from mucus shaken from the mouth into the larynx, and vomiting, produced by moving the patient into the theatre from an adjoining room.

The proper place, in private practice, for the induction of anæsthesia is upon the operating-table itself, which will not afterwards require to be moved until recovery takes place.

It is a mistake to suppose that children are best anæsthetized in their own cots, the high metal sides of these being quite unsuitable for the administrator's control of the child and adjustment of his mask and other apparatus. When children warmly wrapped in a blanket have been brought into another room by the nurse, and laid upon the operating-table, the author has not observed them to be frightened, but only mildly interested at the unusual aspect of the room, and far more obedient than in their cots, which they regard as their own particular property.

When circumstances compel a patient to be moved in the anæsthetized state before an operation, the best method of effecting the transit is the following:

Two or three persons, according to requirement, should first stand in a line by the bedside.

The head-lifter should pass one hand beneath the patient's neck and distant shoulder, and grasp the farther arm above the elbow. He allows the patient's head, the face being turned away from him, to rest upon his own biceps, and with his other hand supports the back.

The body and foot lifters take the pelvis and legs. They now draw the patient towards them, and, raising him to the level of their chests, walk to the operating-table.

Those who lift a patient should never stand on opposite sides of the body, because (1) they take up too much space to pass through doorways or easily traverse an ordinary furnished bedroom; (2) the lifting-power is much greater when the patient's body can be held close up to the lifters—that is, when the latter can

bring their feet beneath the centre of gravity of their own bodies plus the lifted weight; (3) the lifters on one of the sides will find themselves between the patient and the table or bed when they arrive there, necessitating an awkward scuffle to get out of the way, and leaving the whole weight to be borne by those on the patient's other side while they do so.

Before transferring the patient, the position of the operating-table with regard to the bed is a point which is frequently unconsidered, and this is more commonly so when both are in the same room, and *after* the operation has been completed.

The rule is this: Arrange the table at a right angle to the bed, with its foot towards the head of the bed, or with its head towards the foot of the bed.

The two lifters stand within the clear triangle of floor-space thus formed, and, raising the patient from the table, make a quarter-circle turn to deposit him upon the bed.

This principle can be applied whenever it is easy to turn the table approximately into either position. When the table and bed are parallel, but foot to head, the lifters stand *between* the two, raise the patient from the table, and make a *half*-circle turn to deposit him upon the bed.

When the table and bed are parallel, head to head, and there is not room to turn the table to a right angle, the lifters stand on the farther side of the table, and a third person draws the table away as they raise the patient and advance straight towards the bed.

These movements are elementary in their simplicity,

and increase the safety and smoothness of the whole operation.

There can be no excuse for the dangerous practice of shuffling patients off a table placed next to the bed, for the patient is liable to fall on the floor between the two, because the lifters are at a mechanical disadvantage in raising a weight at such a distance from its centre of gravity.

In carrying partly anæsthetized patients up or down stairs, the *head-down* position must be adopted. The force of gravity will then aid in keeping the cerebral centres full of blood, and prevent faintness; and if vomiting take place, the ejected matter is more likely to pass out of the mouth than into the larynx.

Hot-water bottles must never be applied to the skin surface of a person partly or wholly under the influence of an anæsthetic, for while insensitive to the heat many cases of severe burns have occurred from this cause. The safest method is to warm the table and bed with bottles before the patient is laid upon them, and then remove them, but to trust entirely to warm blankets during operation, and afterwards in bed, until complete consciousness and sensation are restored.

The patient's clothing for an operation must be quite loose, though warm.

In the case of nitrous oxide, which is commonly administered in the day clothing, care must be taken that females actually unloosen their corsets, for the author has seen hesitating, irregular breathing, and in two instances complete respiratory cessation, due entirely to tight corsets. Patients who object to do this must be told in the presence of a witness that they

will be required to breathe "from the waist," and that, if these instructions are not complied with, the doctor cannot undertake the responsibility of the administration. Thin females with narrow hips are apt to lace tightly, not so much from vanity as in order to support the weight of the clothing which hangs from the waist.

During surgical operations, when the patient has lung trouble or is very feeble, a wadding jacket next to the skin is sometimes used with advantage, and long worsted stockings reaching well above the knees should always be worn if the nature of the surgeon's work permit.

Artificial teeth should always be removed, unless they be fixed bridges, crowns, or pivoted teeth, which the anæsthetist must ask for, look at, and note for special care, when a mouth-prop or gag has to be inserted.

A common error is made in supplying only one blanket to cover the patient during operation. Two separate blankets are required, as heat is always lost during anæsthesia.

For abdominal operations these can be doubled, and used, one to wrap up the legs and feet, and the other to cover the arms and chest.

A patient's arms must not be allowed to hang down over the sides of an operating-table, in case pressure upon its edge should cause paralysis of the musculo-spiral nerves. This can be prevented by passing a doubled piece of bandage behind the patient's neck, supporting both wrists as in a double sling (see Plate III.).

When Clover's crutch is used to maintain the litho-

tomy position, its leather circlets should be fastened below the patient's knees, and the neck strap passed over one shoulder and out beneath the other axilla, in order to prevent undue local pressure either in the popliteal spaces or over the clavicles.

The surgeon's or assistant's arms must not be allowed to press upon the patient's chest during anæsthesia, nor any other form of pressure be permitted, for this alone may bring the breathing to a standstill.

FIG. 1.—OPERATING-TABLE, SHOWING SCREEN TO SHUT OFF OPERATION AREA FROM PATIENT'S EXPIRATIONS. PATERSON'S ARM SUPPORT AND MAYO'S INSTRUMENT TRAY.

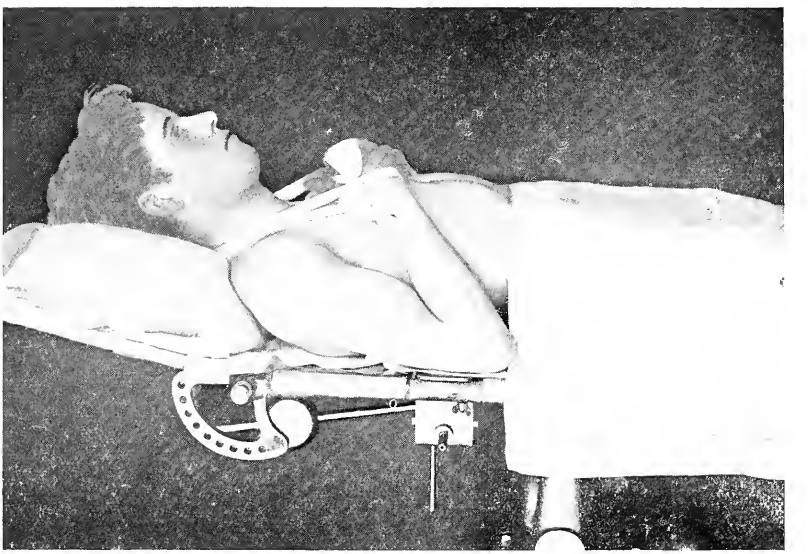

FIG. 2.—SUPINE POSITION. THREE-INCH BANDAGE USED AS A DOUBLE SLING TO PREVENT ARMS FALLING OVER EDGE OF TABLE.

To face page 80.

CHAPTER IX

NITROUS OXIDE

PROPERTIES.—Nitrous oxide (N_2O), generally known as "laughing gas," or simply "gas," was chemically discovered by Priestley in 1772, and used for general anæsthesia by Horace Wells in 1844.

It is a colourless, transparent gas of specific gravity 1·5, as compared with air at 1, and is prepared by heating nitrate of ammonium. Its taste and odour during administration have been aptly described by a child as that of "sugar and air"; but its odour is imperceptible when it escapes into the atmosphere of a closed room. It was first liquefied by Faraday in 1823. To maintain it in the liquid state requires a pressure of 50 atmospheres at 44·6° F.

The steel cylinders in which liquid nitrous oxide is supplied at the present day are made to withstand a pressure of 220 atmospheres or more, in order to provide for the increased expansive force produced by higher surrounding temperatures; but they must not be exposed to heat nor dropped upon hard surfaces, in case they should explode.

PHYSIOLOGICAL ACTION.—By nitrous oxide, according to the experiments of Pickering,[1] the heart's action of an embryo chick was arrested after several

[1] Pickering, Transactions of the Odontological Society, December, 1893, p. 46.

minutes' exposure to the gas. A mixture of nitrous oxide with 30 per cent. of carbonic acid gas stopped the heart in thirty seconds, but a mixture of nitrous oxide with 30 per cent. of oxygen stimulated the heart, which still acted after several hours' exposure to the mixture.

Sir F. Hewitt,[1] quoting from Kemp's researches, states that nitrous oxide is very soluble in blood, but that there is no definite evidence that this anæsthetic forms any combination with hæmatin or any other constituent of the blood, although some such association is regarded by many as highly probable.

It does not support life, for it yields no oxygen to the blood, but displaces it, and is eliminated unchanged.

According to Kemp's[2] tracings, the blood-pressure under pure nitrous oxide is markedly raised, and the results obtained were clearly parallel to those observed in asphyxia.

In the presence of an adequate supply of oxygen the author has found the heart's action and blood-pressure to be either normal or very slightly increased, whilst the asphyxial effects are entirely abrogated.

The admission of the largest quantity of air compatible with successful anæsthesia (about 30 per cent. containing about 6 per cent. of oxygen and 24 per cent. of nitrogen) is not sufficient either to maintain the heart's action and blood-pressure at the normal level or to completely abolish the anoxæmic factors of nitrous oxide.

As before indicated, nitrous oxide is without irritating properties when inhaled, and does not cause coughing,

[1] "Anæsthetics," p. 73.

[2] Kemp, *British Medical Journal*, November 20, 1897, p. 1482.

though in florid persons and children a considerable secretion of saliva sometimes takes place, which may tend to produce attempts at swallowing, unless in the sitting position the head be kept upright, so that the fluid may flow forwards, or when lying supine the head be turned to the side for the same purpose. The initial sensations are those of pleasant exhilaration, with slight intensification of hearing, so that the external sounds are much magnified, and a drumming or throbbing sensation in the head and ears is sometimes experienced.

In the case of the unmixed gas, a tendency to breathe deeper and faster then supervenes, and (except in extremely alcoholic and partially insane patients, who may become almost unmanageable under gas) consciousness is suddenly lost at about the fifteenth respiration. The breathing then grows deeper and more forcible, stertor becomes audible, and a hesitation in respiration, followed by jactitation or mild convulsive movements of the limbs, supervenes. There is always some blueness of the lips and face at this moment, whilst the eyes are open and directed upwards with widely dilated pupils.

This picture is not a pleasant one, and represents the state of anoxæmia which may be produced, either with or without an anæsthetic, whenever, either chemically or mechanically, oxygen is suddenly withheld from the human organism. If the administration be discontinued at the moment of the first irregularity in breathing, a period varying from twenty to fifty seconds of complete anæsthesia is obtained, during which it is possible to remove teeth, incise abscesses, or perform any similarly rapid operation, without pain.

Nitrous oxide in any sequence or mixture should *never* be administered unless the teeth or gums have been separated beforehand by means of a mouth prop or gag, on account of the masseteric spasm and clenching of the teeth which accompanies the anoxæmic state.

From this description it is quite evident that nitrous oxide, when given unmixed with air or oxygen, is an asphyxiant, and that its further administration becomes impossible directly the signs of anoxæmia appear. The average time which elapses before these occur may perhaps be given as sixty seconds, but in anæmic, highly nervous, and very plethoric persons, may be much less.

The general safety of nitrous oxide no doubt depends upon several circumstances, but the fact that its administration is thus automatically limited by convulsive and inconvenient movements of the body and limbs has contributed greatly to prevent overdosage, whilst the further fact that recovery from its effects is so rapid gives great assistance to remedial measures when required.

APPARATUS.—In the process of evaporation from the liquid state in the steel cylinders, when the tap is opened, the gas absorbs heat from its environment, with the result that the cylinder itself is cooled to a low temperature. As it falls below the dew-point of the surrounding air, aqueous vapour condenses upon the outer surface of the cylinder, and then freezes, producing a layer of frost, in thickness dependent upon the duration of the gaseous escape. Thus, a bottle used for one patient—*i.e.*, in delivering 6 or 7 gallons of gas—may become merely damp externally, but after three or four times this quantity has escaped

the bottle will be coated with white rime, and will freeze the skin when handled.

It is stated that solid nitrous oxide is sometimes formed within the bottles by the fall of temperature and the rise of gas pressure which occurs when the tap is opened, and that this solid may then block the orifice of the tap-valve; but the author is of opinion that the loose iron rust formed within the bottles after long use, which can occasionally be heard rattling about if they are shaken, is more often the cause of valve-blocking, and that the rust should be thoroughly cleared out each time by the makers when the cylinders are refilled. Seven and a half ounces of liquid nitrous oxide yield 25 gallons of the gas, and the best test of the quantity within at any given time is afforded by weighing the bottle, its weight both full and empty being stated on the label by the best makers.

By holding a bottle lightly at the screw end, and tapping the lower part gently with a spanner or foot-key, an indication of its contents may be obtained by the resonant note elicited when there is liquid within, a duller and more stony sound being yielded by an empty bottle. The forcible escape of gas on gently turning the valve-screw of a fairly full bottle, as contrasted with the soft hiss of a nearly empty one, is also used as a test by many experienced administrators. The 25-gallon size of nitrous oxide cylinder is convenient for use in private practice, and the 50- or 100-gallon size for hospital work, where a number of patients have to be taken consecutively or a long administration is contemplated.

It should be made an invariable rule to use two bottles coupled together, in case of faulty working,

blockage, or unexpected exhaustion of the one in use.

For dental purposes, on the average three patients may be anæsthetized from a 25-gallon bottle; but the quantity used depends on the duration of the administration, which is longer when air or oxygen is admitted than with unmixed nitrous oxide.

The metal spikes of foot-keys employed for turning the taps should be kept sharp with a file, so that the issue of gas may be exactly controlled by the movements of the sole of the boot pressed upon them.

Leather washers are necessary at the junctions of the couplings and cylinder screws to prevent leakage, for imperfect jointing sometimes results in the sucking in of unknown quantities of air, as well as the escape of nitrous oxide. The rubber tubing from the cylinders to the gas-bag should at least be $4\frac{1}{2}$ feet in length, to allow for the raising of the dental chair for extraction of the upper teeth.

Indiarubber tubing and bags last for several years in constant use, but two factors in their early decay are cold and damp. They should, therefore, be gently warmed once a week when not required for administration, to keep them flexible, and, if washed, should be thoroughly dried at once. White patches result from contact with water, but these disappear on exposure to dry air. Stickiness of rubber parts is a sign of perishing, and they must then be discarded. Rubber valves require renewal every few months, for the success of nitrous oxide inhalation largely depends upon their integrity and coaptation. The air-cushions of face-pieces should be kept constantly distended, for, when

collapsed, adhesion of their internal surfaces with perishing is liable to occur.

No economy is effected by the purchase of cheap forms of apparatus, for numerous unexpected faults are common to them. The punching of holes in the metal discs and other parts is resorted to instead of drilling by the manufacturers of inferior stopcocks, with the effect of disturbing the precision of their planes and curves, and rendering the accurate fitting of valves impossible when laid upon them. The fatal fault of many kinds of nitrous oxide apparatus sold at the present time is the small calibre of their breathing channels, which introduces a mechanical asphyxial factor entirely deleterious to successful anæsthesia.

The narrowest portion through which the gas passes after leaving the bag should be made not less than ¾ inch in diameter—*i.e.*, considerably larger than the largest human trachea.

Nitrous oxide which has been kept in a gasometer with a water seal is liable to contain a small proportion of air, which accounts for the slight difference in the symptoms produced by its inhalation.

THE ADMINISTRATION OF SIMPLE NITROUS OXIDE.—It is better that the patient should abstain from food for three or four hours before taking nitrous oxide gas, in order that no tendency to vomiting should arise from the presence of an undigested meal in the stomach. Faintness and tendency to sickness in men may be avoided by abstinence from tobacco-smoking for two hours before and an hour after the inhalation. A slight feeling of giddiness, numbness, or tingling in the hands and feet, may persist for a few minutes after recovery from unconsciousness; but, apart from

the result of swallowing blood and the reaction from extreme fear, the after-effects of nitrous oxide are almost negligible.

Boys of all ages up to eighteen years are particularly apt to be sick after the gas, but the cause of this is not clear, as they are quite the exception to the general rule.

The Administration.—If the patient be already seated in the dental chair, with clothing loosened around the neck and waist according to instruction, it is well for the anæsthetist to reassure him by saying that the induction of anæsthesia is a very simple matter, and that the anæsthetic is almost tasteless.

Whilst doing so he will be able to observe the patient's physique, nervous activity, chest capacity, muscular development, facial colour, and probable age; for these factors collectively constitute the physical type to be dealt with, and modify in different ways the conduct and technique of the administration.

Most persons about to take nitrous oxide or ether expect to be assured that their heart is strong enough to stand it, and it is always best for the administrator to feel the radial pulse, and listen to the heart sounds with a stethoscope, in order to ascertain whether this be the case. If a suspicion of cardiac valvular or muscular incompetence be suggested by smallness, irregularity, feebleness of beat, or intermission of the pulse, a further examination of the heart should be made. The only strain thrown upon the circulation by this anæsthetic is secondary to interference with the respiratory functions, which should never be allowed to occur throughout the entire period of unconsciousness.

A word may be said in passing as to the point of

view from which the anæsthetist should conduct the administration. In the first place, the successful result and issue of the proceeding will be very largely due to his experience and resource in smoothly overcoming the patient's possible apprehensions and nervousness, and in really assisting the dental surgeon, so that the tooth or teeth may be removed without any pain. Let him say to himself: "This has to be done well or not at all. If I feel that I have not obtained sufficient experience, I will go to the nearest hospital or dispensary, where I may administer nitrous oxide to several cases for a similar purpose. I shall then see what is wanted, and it will not be my fault if the extraction is not successful." The reason for this need of actual experience is that the mechanical efforts of keeping the gas-bag partly full by the use of the foot-key, the face-piece in accurate apposition, the mouth-prop in its proper place, of changing the prop for the Mason's gag, holding the patient's head during the extractions, and making certain that no foreign substances pass into the throat, are as difficult to do without proper practice as it is for a musician to play a harmonium with one hand and foot and conduct an orchestra with the other hand.

With regard to posture, the cardinal principle that the patient should sit as upright as possible in the chair, with the head in a line with the body, neither extended backwards nor flexed upon the chest, has been clearly laid down by Dr. Hewitt. Early stertor from falling back of the tongue almost always ensues when the patient is allowed to lie backwards, and no satisfactory anæsthesia can possibly be induced in that position.

Another important point, when the patient is tall and powerful, is to *place his feet either with the heels resting upon the floor at the sides of the foot-rest, or upon the top of the latter*, instead of against it. This will prevent any reflex movement of the limbs disturbing his posture, as it affords no fulcrum from which he may drive the body upwards and backwards during the operation.

It is also useful to ask the patient to *clasp his two hands together, with the fingers interlaced*, for it gives him confidence to have something to hold firmly, and, as the grip tightens during unconsciousness, it

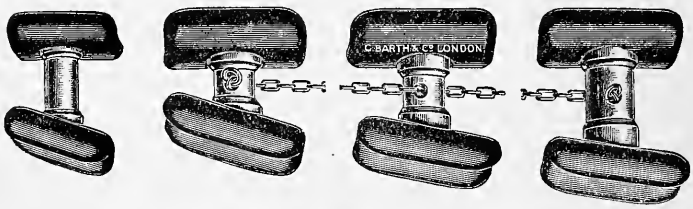

Fig. 1.—Hewitt's Dental Mouth-Props.

keeps his hands out of the way of the apparatus and of the operator throughout.

Mouth-props are best made according to Dr. Hewitt's pattern—in one piece, without screws, springs, or movement of any kind. These are to be placed upon the molar teeth on the opposite side of the mouth to the extractions, and kept there during induction of anæsthesia and during the operation by the anæsthetist, who for this purpose should make slight upward pressure upon the mandible with his left hand.

The next step is to choose a face-piece of suitable size.

The object during the induction of anæsthesia with

nitrous oxide is to make the face-piece fit accurately, to the exclusion of all air while it is held against the face, and this can nearly always be done best by choos-

FIG. 2.—HEWITT'S NITROUS OXIDE GAS APPARATUS.

ing the smallest-sized face-piece which will cover the nose and mouth from an inch below the margin of the lower lip to the bony bridge of the nose above, in-

cluding the angles of the mouth at the sides when propped open as for extraction. Larger face-pieces than this are apt to bulge out and admit air somewhere without the administrator's knowledge, and will prove a fatal hindrance to perfect anæsthesia.

If the patient has a beard, or other conditions prevent the face-piece from fitting accurately, the gas-bag should be kept quite full, so that an unknown amount of air may not be admitted beneath the face-piece, but rather a little gas may escape through the interstices from within.

The instructions to be given to a patient before breathing the anæsthetic should be as simple as possible, the best way to induce regular respiration being to tell him to *breathe out slowly through the mouth;* for if his attention be directed to expiration, inspiration will follow automatically, without any sense of suffocation.

A great deal of discomfort—and, in fact, sometimes complete refusal to take any more nitrous oxide—will result from a patient being allowed to partly hold his breath during the first few inspirations; and although nitrous oxide is almost tasteless, a nervous person will often breathe irregularly without a few words of encouragement from the anæsthetist.

The anæsthetist stands at the left side of the dental chair, and having filled the gas-bag two-thirds full, and ascertained that the valves are in working order, takes the face-piece in his left hand, and, supporting the patient's chin with his third and fourth fingers, applies the face-piece evenly to the patient's face, from the root of the lower lip to the bridge of the nose, by means of his first and second fingers on the farther side and his thumb upon the nearer one.

He then tells the patient to breathe out slowly through the mouth, and by turning the foot-key slowly lets into the bag enough gas to keep it two-thirds full throughout. Patients always fear that they will be operated upon before they are "off," so that it is well to say: "You will not be asleep yet, but when you have gone to sleep I shall test you to see that you are insensitive before you are touched." After about fifteen breaths consciousness is suddenly lost, voluntary trembling of the upper eyelid ceases, and, if one eyelid be elevated, the eyeball will be found to be gradually travelling upward in its vertical axis and the pupil growing larger. The breathing grows a little deeper and more regular, and the colour of the face a trifle dusky, at the end of thirty or thirty-five respirations. Some stertor from the falling backwards of the paralyzed tongue now ensues, and a halt or hesitation in breathing takes place, immediately followed by muscular jactitation of the limbs and jerky respiration. The face is now cyanosed, the eyes open and directed upwards, with widely dilated pupils. This stage is reached after about fifty to sixty seconds from the first breath of nitrous oxide gas. If the face-piece be now removed after the warning words "Get ready" and "Now" to the dentist, about thirty to thirty-five seconds' available anæsthesia will result.

The anæsthetist during the operation should note the returning colour of the face, and keep one of the patient's eyelids open, watching the eye for contraction of the pupil and returning voluntary ocular movement. Directly this occurs, he should say "Stop." If the dentist then cease extracting, no pain will have

been felt, because sensation to pain is the last faculty to return after general anæsthesia.

The patient's hearing is very acute both during "going off" and "coming round," so that neither dentist nor anæsthetist should talk during the operation.

Many dentists have a habit of saying, "It won't come," or "Have I time?" or "That's two; there's another," while extracting; and though the patient feels nothing, he will most certainly remember to have heard the words, and repeat them, thinking that he was awake all the time.

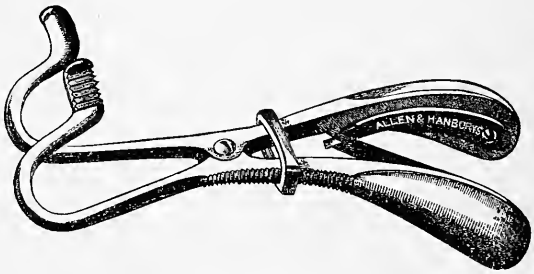

Fig. 3.—Mason's Gag.

Silence whilst operating is a golden rule set with many diamonds.

If both sides of the mouth have to be operated upon, the anæsthetist, at the word "Change" from the operator, should slip the Mason's gag into that side of the mouth where extractions have first been made, and draw the prop out from the other side, thus keeping the mouth continuously open, and alternate sides free for the operator to work upon. The Mason's gag is best introduced with its blades closed in the central line of the open mouth, and then gradually opened as it is drawn towards the side; for in this way the

blades will not bruise the patient's lips against his teeth.

During the extraction of upper teeth, the anæsthetist may be of considerable assistance by steadying the patient's head and exerting counter-pressure upon the top of the patient's forehead.

While lower teeth are being removed, counter-pressure from below upwards upon the mandible will not only prevent subluxation of the jaw, but assist in keeping the prop where it was first inserted. It must be borne in mind that for extracting right lower teeth the dentist sometimes desires to stand behind the patient, and the anæsthetist should then be prepared to stand farther forward than usual. In the case of a left-handed dentist, the anæsthetist must stand on the right side of the patient; but it must be admitted that considerable practice is required to become really ambidextrous.

For the removal of wisdom-teeth, the mouth should not be so widely opened as to stretch the cheek tightly, because the operator cannot move his forceps outwards against the rigid wall of muscle, and the coronoid process of the lower jaw in that position may also prevent the forceps from getting a good hold of an upper wisdom-tooth.

NITROUS OXIDE AND AIR.—Of recent years many improvements in the administration of nitrous oxide gas have taken place, with the object of avoiding some of the asphyxial characters of the anæsthesia, and also of prolonging the time during which it may be maintained.

The first method is to give a breath of air after about ten respirations of nitrous oxide, and then

another breath of air after each five respirations following, till a condition of anæsthesia is reached with only mild stertor and a moderate change of colour, when the face-piece can be removed, and a few seconds' longer anæsthesia may be anticipated than with nitrous oxide *per se*. This method of admitting air must be done with considerable judgment, for, though very suitable for feeble and anæmic persons and women, only a small amount of air can be given to powerful subjects of either sex and to alcoholics; for in such cases the admixture of air often causes them to move inconveniently, or even to become almost unmanageable. With practice, however, small percentages of air, varying actually from 3 to 30 per cent., may be admitted in almost all cases, with reduction of jactitation, blueness, and stertor, and increased length of resulting anæsthesia.

The actual time taken in arriving at the acme of anæsthesia is longer than with nitrous oxide alone, varying from one and a half to one and three-quarter minutes from the commencement of the inhalation.

Prolonged Anæsthesia with Nitrous Oxide and Air.—In administering nitrous oxide and air by means of Mr. Herbert Paterson's nasal apparatus, great care and experience are required to attain the tranquillity and freedom from asphyxial symptoms which are characteristic of the oxygen method described below; but the fact that perfect insensibility to pain can be maintained during the extraction of a large number of teeth is now established, and under favourable circumstances this plan can be made a most valuable addition to the resources of the anæsthetist.

The author has employed the nose-piece extensively

since 1899, and can speak from intimate experience of the many cases in which it has rendered the use of ether unnecessary for the extraction of impacted wisdom-teeth, for cutting off and drilling out the nerves of teeth about to be crowned, for removing several buried stumps, and other procedures which may require three or four minutes' anæsthesia.

The apparatus itself is simple, and consists of a supply-pipe from the gas-bottles leading to a small, strongly made rubber bag with a two-way stopcock connected by two rubber tubes to the sides of an aluminium nose-piece of just sufficient size to include and cover the patient's nose. This is fitted with an air-cushion to prevent discomfort from pressure upon the face.

The nose-piece can be easily detached and washed after each case. The bag is to be hooked on to the back of the dental chair, and the nose-piece held by the administrator in his right hand, whilst he stands behind and slightly to the left of the patient's head, and controls the supply of nitrous oxide with his right foot. A mouth-cover with an expiratory valve fitted to it is also occasionally necessary, but in 75 per cent. of cases it is not required.

There should be no valves in the apparatus, because it is less uncomfortable for the patient to breathe to and fro through his nose during the first few breaths than to discover that he cannot expire at all through the nose before he is unconscious. The best plan is to adjust the nose-piece, and permit a few respirations to be made through the nose; then, when the patient has become a little confused by the action of the anæsthetic, to pass a definite stream of gas through the

nose by slightly distending the bag, and thus filling the air-passages sufficiently to produce anæsthesia.

It would no doubt be anticipated that a large

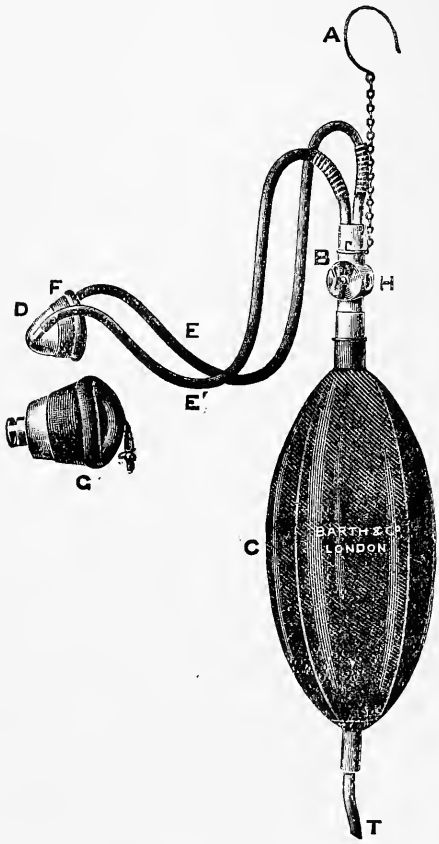

Fig. 4.—Paterson's Nasal Apparatus for Nitrous Oxide and Air Administration.

amount of air would enter by the mouth, as it is propped open from the beginning in the usual manner for the ordinary method; but in actual practice this does not occur unless the pressure of gas is too slight to keep

the soft palate forward and maintain nasal breathing. A point which is not apparent at first sight now becomes evident—namely, that the success of the method largely depends upon the integrity of the soft palate.

However, by naso-oral direction of the respiration with the mouth-cover *ab initio*, in a very severe case of cleft palate, the author has succeeded in maintaining perfect anæsthesia, so that a communication between the nose and mouth is not a complete bar to the use of the nose-piece. Numerous cases with partial nasal obstruction, and others with adenoids, have proved excellent subjects for this form of administration, because a stream of gas under slight pressure will pass through the narrowed airway without difficulty, where ordinary inspiration would be inadequate to fill the lungs. As a further example, if the nasal airway be halved in calibre by some obstruction, the stream of gas can readily be doubled to meet the requirements of the case.

There remains, therefore, only the one class of patient who suffers from complete nasal obstruction for whom this method is inapplicable. Before going farther, it is right to warn intending administrators that the mere fact of prolonging nitrous oxide anæsthesia increases the danger of over-dosage, and that a full supply of air must be given through the stopcock by admitting it at every third or fourth inspiration directly after unconsciousness has set in. It is really unnecessary to procure a deep anæsthesia at all by this method, for, supposing the passage into profound anæsthesia to be divided into ten degrees on a scale, and that it is necessary to advance as far as degree number eight, when giving gas in the ordinary way, so that

the patient may feel no pain until he emerges from sleep as far as degree number two, then with the nasal apparatus it will be unnecessary to push the anæsthesia further than degree number five, because this exact degree can be maintained as long as required. A kind of expiratory stridor sets in at the moment the patient becomes unconscious, caused by the blowing forward of the soft palate, and this is a good time to begin the operation. If a patient is liable to secrete much saliva and mucus in the mouth, a preliminary gargle of weak Condy's fluid or solution of alum has been found to reduce its quantity. Excessive secretion of mucus may become especially troublesome when fine dust flying from the dental drill falls upon the tongue or against the pharynx during anæsthesia. This may be prevented by guarding the oral cavity behind the drill with a sponge. It is more important not to let the patient rest his feet against the end of the dental chair, and thus perhaps straighten himself out, than it is with the single-dose method of giving gas, because, if the head be thus extended backwards, the tongue may fall against the pharynx and prevent the prolongation of anæsthesia.

NITROUS OXIDE WITH OXYGEN.—In the first place it should be remembered that oxygen is in no sense an anæsthetic, and is mixed with the nitrous oxide entirely for the purpose of preventing the occurrence of asphyxial symptoms. It renders the inhalation capable of supporting life, and is required in different quantities by various types of patient.

For instance, among healthy subjects, those who are florid and well nourished will require less added oxygen than those who are sallow and of slender build,

because the initial supply of oxyhæmoglobin contained in their blood is larger in amount.

To patients whose blood, circulatory system, or respiratory mechanism, is in any way impaired, a much larger supply of oxygen should be given, in order to compensate for the tendency to oxygen starvation from which they already suffer. The administrator must always especially watch for cyanosis when the subject appears to have a poor degree of chest expansion, for he may then suspect previous bronchitis, pleurisy, asthma, or tuberculosis. Existing emphysema also greatly delays the due interchange of gases in the lungs.

Tight lacing in women produces a similar result, and no anæsthetic should ever be given unless the thoracic wall is quite free from such mechanical restriction.

In the conditions above mentioned oxygen is of the greatest value to the administrator, and its adjuvant properties are also well marked in highly nervous patients, who are apt otherwise to develop muscular jactitation early in the inhalation.

Greater allowance of oxygen should always be made for patients above middle age, and although it may be found that their nervous and mental activity often seems to make them somewhat resistant to the effects of the anæsthetic, they should not, however, be rendered at all cyanotic, for the general circulation is at this time of life far less fitted to stand any asphyxial strain without the possibility of damage to the vessels or secondary cardiac depression.

In quite normal individuals the addition of oxygen always permits a longer anæsthesia of a more tran-

quil nature than that of nitrous oxide alone, and when to this is added the fact that the patient's aspect under

Fig. 5.—Hewitt's Nitrous Oxide and Oxygen Apparatus.

its influence is in no way alarming to an onlooker, its advantage and safety can be duly estimated. The administration is best conducted by using the re-

FIG. 1.—CORRECT POSTURE FOR DENTAL ANÆSTHESIA.

Head in line with body. Hands clasped in lap, with fingers interlaced. Feet over chair-end to prevent extension of legs.

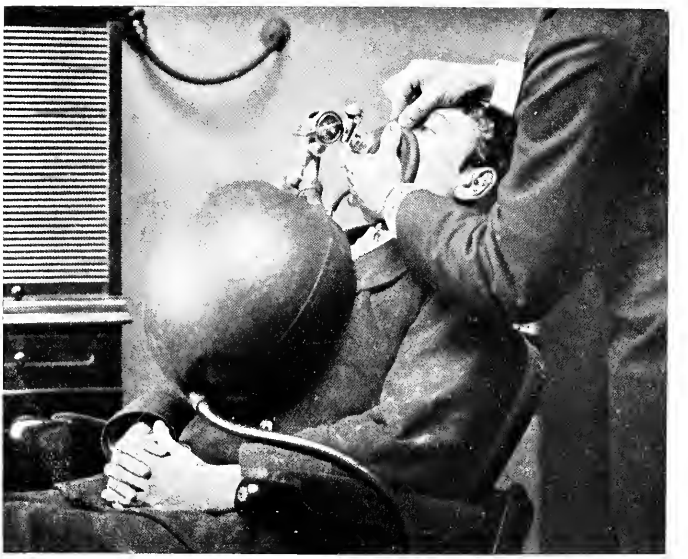

FIG. 2.—NITROUS OXIDE AND OXYGEN WITH HEWITT'S APPARATUS.

Anæsthetist supporting chin with left third and fourth fingers, and preventing air leakage with right finger and thumb.

To face page 102.

spiration as the chief guide. Commencing with nitrous oxide and 2 per cent. of oxygen, we should wait until after five or six breaths a rather deeper breathing sets in, and then increase to 4 per cent., then to 6 per cent., of oxygen, according to the type of patient, aiming to produce audible respiration of normal rate. If the breathing be deeper than this, the oxygen should be increased till this object is attained; if more shallow, the oxygen should be decreased to produce the same result, remembering that good anæsthesia always takes one and a half to two minutes, or even longer, to produce.

Soft snoring, if the head be neither flexed nor extended backwards, is an excellent indication for beginning the operation; but the eyes afford the most invariably reliable sign of complete insensibility. The eyeballs exhibit a kind of preliminary vertical nystagmus before they come to rest, and finally become fixed, with the pupils moderately contracted and looking in a downward direction.

If the presence of large tonsils or the secretion of mucus in the mouth during the inhalation produces a stertorous sound, or gulping or retching movements, these will, as a rule, be quite abolished by tilting the head forwards, the anæsthetist, to effect this, passing his right arm behind the patient's neck, which still leaves his right hand free to continue the regulation of the gases.

As to returning consciousness, it is often difficult to say exactly when the operator should stop in order that the patient may feel no pain whatever; but as sight and hearing return before sensation to pain, it is best to watch the patient's eye, and, if it be closed during the operation, to elevate the eyelid. When

the first voluntary movement of the eye in "looking round" occurs (usually an effort on the part of the patient to find out where he is after his dream has vanished), the operator should immediately be warned to stop.

This will never fail to prevent tranquillity being mistaken for anæsthesia.

Continuous Anæsthesia under Nitrous Oxide and Oxygen for Dental Operations.—The advantages to be obtained from the induction of a safe general anæsthesia, of ten minutes' duration if required, for dental operations, need no indication when the difficulty of accomplishing certain manipulations in the mouth within the fifty seconds yielded by a single dose of nitrous oxide and oxygen is seriously considered.

The very great help which the author has obtained from the use of the combined apparatus now to be described for the induction and continuation of anæsthesia with nitrous oxide and oxygen, during the extraction of impacted single teeth, buried roots, or a number of teeth and stumps, and also during the cutting off, drilling, and devitalization operations upon the teeth, shows the gain to be more than one of time alone.

The abolition of the need for haste on the part of the dental surgeon renders his work more accurate, whilst its completion may be promised beforehand with greater certainty of success.

Nitrous oxide with adequate percentages of oxygen has been administered for surgical operations in suitable cases for various periods lasting up to two hours and a quarter in duration,[1] and, as in the case of ether

[1] Mr. H. J. Paterson, Transactions of the Society of Anæsthetists, vol. v., p. 153.

and chloroform, there is no physiological time limit to its safe inhalation.

The after-effects of the continuous administration for periods from three to ten minutes in duration in the dental chair are, in the writer's experience, remarkable chiefly by their absence, and do not, in fact, surpass those of a single dose. It is best that the anæsthetic should be taken four hours after a light meal. So comfortable and tranquil is the anæsthesia that a large number of patients who have previously taken nitrous oxide and oxygen by the ordinary method have expressed a preference for this one, on account of the certainty that they will not awake before the completion of the operation. When it is known that the extraction will probably be difficult, it is far better, with such a convenient means at hand, to utilize it rather than trust to good-fortune during the fifty seconds of one dose.

The inhaler consists of Mr. H. J. Paterson's nose-piece, with tubes leading to the mixing chamber of Sir F. Hewitt's portable nitrous oxide and oxygen apparatus, which is fitted with Dr. A. G. Levy's double rubber bag connected by concentric tubing to the gas cylinders. A mouth-cover with expiratory valve is also added and occasionally required.

Fig. 6 shows a section of the apparatus and a view of the valve chimney, which when left *in situ* allows the inhaler to be used with a face-piece for the administration of a single dose of nitrous oxide and oxygen by the ordinary method, but when removed and reversed leaves the breathing channels free from any valves, and allows rebreathing to take place if required.

Before Dr. A. G. Levy demonstrated his invention, which consisted in placing the oxygen bag within the nitrous oxide bag, rendering the pressures within both bags always identical, provided that the inter-

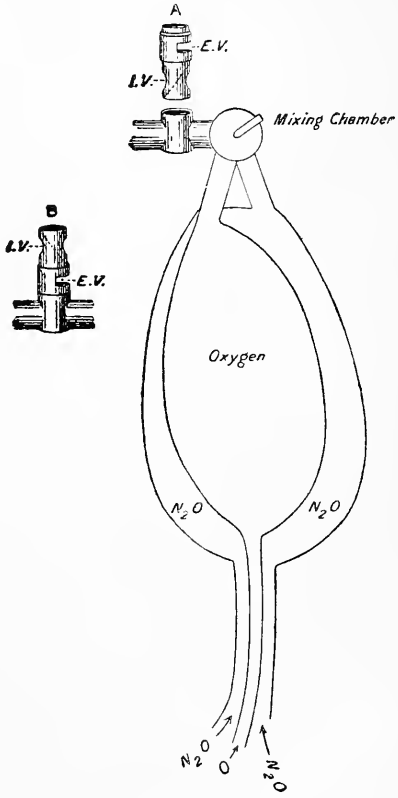

Fig. 6.—A, Reversible Chimney removed; B, Chimney reversed for Nasal Method. Valves out of Action.

nal one be not distended, it had not been possible to add variable percentages of oxygen to nitrous oxide given through the nose-piece, because the slight plus pressure required for this method, when applied to

one of two parallel bags, was found to disturb the proportions of the gaseous flow through the mixing chamber.

Though Dr. Levy's invention was intended only for improving the accuracy of Sir F. Hewitt's original apparatus, the author found that it supplied the means for adapting the latter to the nasal method, and he therefore had this combined apparatus constructed, enlarging the oxygen bag to obviate the necessity of refilling it during the administration, and providing a removable and reversible valve chimney, with the view of obtaining a means of supplying nitrous oxide with variable percentages of oxygen up to 30 per cent. by continuous nasal administration, arranged in such manner that either to-and-fro nasal breathing or naso-oral respiration under moderate plus pressure might take place.

The induction and maintenance of anæsthesia are thus accomplished.

The mouth is propped open with a rigid Hewitt's prop between the molar teeth. The apparatus having previously been suspended by a metal hook from the back of the dental chair, and the valve chimney taken out and reversed, the nose-piece, held in the anæsthetist's right hand, is carefully adapted over the patient's nose, so that respiration through it is free and comfortable. Nitrous oxide and 6 per cent. of oxygen are then turned on, and rebreathing into the bags begins. This can be seen to occur by the rise and fall of the outer bag. A little nitrous oxide is now gently run in to take the place of that absorbed or lost through the mouth, the bag being thus kept full, but not distended.

The percentage of oxygen is increased to 10 after the lapse of one minute, and then to 15 at the end of a minute and a half, when, as a rule, anæsthesia is complete, with normal colour, tranquil nasal respiration, weakly active corneal reflex, and moderately contracted pupils. The pulse is a little raised in frequency, and of good volume throughout. This anæsthesia can be easily maintained, and the oxygen increased as time passes, to keep the colour bright.

If the patient, instead of breathing through the

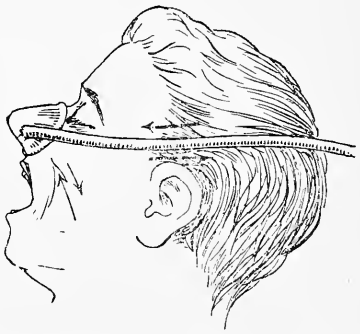

Fig. 7.—Nasal Rebreathing of Nitrous Oxide and Oxygen.

nose, begins to respire through the mouth, the special mouth-piece is then adjusted. A moderate plus pressure at the same time being produced in the inhaling bag, naso-oral respiration then results.

This form of breathing—*i.e.*, nasal inspiration followed by oral expiration—answers well till unconsciousness is attained, and may be continued afterwards, when the mouth-piece is removed, by maintaining the moderate plus pressure in the gas-bags. It will often, however, be found that the to-and-fro nasal breathing will be resumed with the onset of oblivion, and that

the plus pressure may then be relaxed to the slight degree first mentioned.

There are certain mechanical factors in dental operations which, when they arise, may limit the further prolongation of the anæsthesia, and these we must now consider.

For instance, very extensive multiple extractions from both the upper and lower jaws on both sides of the mouth can only be completed if blood be not allowed to run backwards into the pharynx, for, when

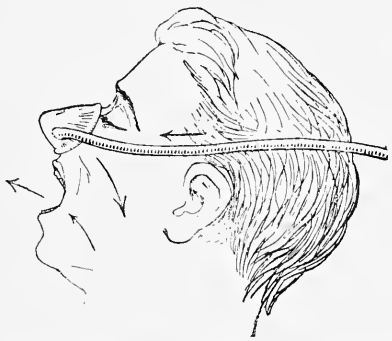

Fig. 8.—Naso-Oral Breathing of Nitrous Oxide and Oxygen.

this occurs, swallowing or retching movements are set up by its contact, which disturb the regularity of the breathing and introduce an element of asphyxia. The flying dust from a dental burr during cutting-off and drilling operations may act also in the same way, unless the tonsils and pharynx be protected by a cloth or sponge placed behind the tooth which is being treated. Strong pressure upon the lower jaw during work upon the lower teeth may, by driving back the base of the tongue, obstruct the airway sufficiently to embarrass respiration.

When extractions have to be made on both sides of the mouth, it is always best to extract the teeth *first* from the jaws on the patient's LEFT side, both upper and lower, so that, when this side has been finished, the administrator, standing at the patient's left side, may more readily pack that side with sponges and then insert a Mason's gag while the right side is being operated upon.

This is essential, because the administrator, having his right hand permanently employed in holding the nose-piece in position, and his left hand intermittently engaged in regulating the percentages of oxygen, can only insert the Mason's gag with his left hand upon the side which is nearer to him.

In this connection it must be borne in mind that the administrator, instead of inducing anæsthesia, and then being free to assist the dental surgeon by supporting the mandible, sponging the gums, etc., as with ether or a single dose of nitrous oxide and oxygen, must, in continuing the administration, keep his attention closely fixed upon the patient's respiration and colour, and upon the supply of gases, so that he cannot afford so much assistance to the operator as with other methods. There being no longer any need for haste, this slight disadvantage, is, however, of small consequence, as the operator may stop to sponge the gums himself if necessary, and then resume his work.

The extraction of a large number of teeth at one sitting is always a matter for careful consideration on the part of the dental surgeon, and if the teeth are likely to offer many difficulties there is not the same objection to the arrangement of two sittings

FIG. 1.—CONTINUOUS NITROUS OXIDE AND OXYGEN.

Apparatus hung from back of chair. Prop between molar teeth.
First Method.—To-and-fro nasal breathing throughout.

FIG. 2.—CONTINUOUS NITROUS OXIDE AND OXYGEN.

Second Method.—Bag slightly distended. Nasal inspiration, oral expiration through mouth-cover, afterwards to be removed.

To face page 110.

as would be the case with ether, on account of the comparative absence of any after-effects under continuous nitrous oxide and oxygen.

In suitable patients the author has frequently induced this form of anæsthesia for what may be termed the immediate devitalization of teeth with inflamed pulps; and with due deference to the opinion which may be held by the dental surgeon in individual cases, it appears to provide a very successful method for the painless destruction of this highly sensitive structure. In most cases an anæsthesia lasting from three to five minutes has proved sufficient to allow the drilling and nerve extraction to be completed, whereas the arsenic method may take several days at the least, involving often considerable pain during the process. The use of cocaine solution for the same purpose may take the best part of an hour for a perfect operation, and may also prove less certain in its anæsthetic action.

Nervousness on the part of the patient is no drawback to success, provided that simple instructions are followed and the behaviour be not unreasonable; but spoilt and unruly children, mentally unstable and eccentric adults, and patients of very powerful build and alcoholic habits, are not likely to prove good subjects for its exhibition.

Taking into consideration its remarkable safety, the absence of any odour in the anæsthetic gases, and the slightness of the after-effects, the method, which has been used in a very large number of cases since 1906, may in the future provide a valuable addition to those already in use.

Certain dental operations require the use of ether, and, excepting that the patient may be safely seated

upright, the method differs in no way from its administration in surgery. The gas-bag is filled with nitrous oxide as far as two-thirds of its capacity, and is then attached to the regulating inhaler,[1] containing $1\frac{1}{2}$ ounces of ether. A small mouth-prop must be inserted between the patient's teeth; then the face-piece is applied, and after five breaths of gas have been inhaled and expired into the air, the valves are thrown out of action, and the ether handle is slowly revolved so as to produce a gradual mixture of ether with the nitrous oxide. When the ether handle has been moved as far as the mark "On," the gas-bag may be detached. The inhalation should proceed until, after the lapse of five or six minutes, the corneal reflex has become decidedly sluggish, for it may then be anticipated that four or five minutes' good anæsthesia will be available for the operation. A number of small honeycomb sponges, about the size of oranges, should be at hand for sponging the gums. When one side of the mouth has been completed, one of these sponges may be packed in between the alveoli, while the other side of the mouth is cleared. If a second dose of ether be required, the patient's head should be tilted well forward while it is given, in order to prevent blood being swallowed, and to permit drainage outwards from the mouth.

[1] See Fig. 15, p. 125.

CHAPTER X

ETHER

PROPERTIES.—Ether or ethyl oxide $(C_2H_5)_2O$ is a clear, mobile liquid, spirituous and pungent in odour and taste, of specific gravity ·720, which boils at 95° to 96° F. The density of its vapour is 2·5 as compared with air at 1, and it therefore tends to sink to the bottom of a bag or to flow downwards from an open inhaler. It is inflammable, and must not be administered nor the liquid poured out within three feet of an open flame or cautery.

There seems to be little clinical difference in the effect produced by the inhalation of the ether prepared by the best makers from methylated spirit and that from ethylic alcohol.

The gradual formation of irritating higher oxides of ethyl in liquid ether after keeping for some time may be prevented by the introduction of a little metallic mercury into the ether bottles in use, which should be washed and freed occasionally from grey deposit.

PHYSIOLOGICAL ACTION.—Ether vapour during inhalation is a cardiac and respiratory stimulant producing a slight initial rise of general blood-pressure, which afterwards remains at nearly normal level.

Owing to its irritating effect upon the respiratory passages, considerable secretion of mucus takes place

within them during inhalation, and this, by obstructing the airways and causing cough, produces one of the chief difficulties in its administration.

Ether is contra-indicated in the presence of pulmonary and bronchial disease.

In toxic doses, the circulation is as a rule well maintained for some time after respiration has been brought to a standstill.

Owing to its volatility and the need for comparative concentration of the vapour breathed to produce complete anæsthesia, ether has been largely administered from a closed or bag inhaler.

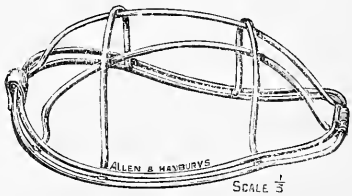

FIG. 9.—AUTHOR'S OPEN ETHER MASK.

METHODS OF ADMINISTRATION—THE OPEN METHOD.—The open method of administering ether has been used in America for several years, and the procedure which the author has adopted, after a series of careful experiments with various materials, consists in pouring ether upon a wire-frame mask covered with sixteen layers of white absorbent gauze such as is used for surgical dressings. The mask, which may be of the Schimmelbusch pattern, or constructed according to the special design shown in Fig. 9, is allowed to rest lightly upon a freshly-made gauze face-pad consisting of several layers of the same gauze made into a roll 14 inches long and 1 inch thick. The free ends

of the roll are crossed and tied together with a short piece of gauze or tape, as shown in Fig. 10, before the mask is applied. An 8-ounce medicine bottle fitted with the double-tubed stopper illustrated in Fig. 11 is well adapted for the supply of ether, which can be poured from the end of either tube at a rate controlled by the finger held upon the other. To diminish the supply still further, the bottle may be held somewhat upon its side, when a small stream of separate drops

Fig. 10.—Author's Open Ether Mask and Gauze Face-Pad.

falls from the tube orifice. A larger stock of ether must also be at hand, as in some cases from 12 to 16 ounces an hour may be required for a long operation.

THE ADMINISTRATION.—1. One hour before the administration a hypodermic injection of atropine sulphate $\frac{1}{100}$ grain is given with the object of preventing the considerable secretion of mucus in the air-passages which may otherwise be caused by ether.

This also prevents sweating during the operation, and thereby retains the body heat. Atropine is also a respiratory stimulant and a vagal obtundent, both valuable qualities unhampered by contra-indications. Morphine is not advantageous for routine employment, because it appears to induce undue oozing of blood from the wound during operation, and certainly retards the reappearance of the laryngeal reflex and the resumption of consciousness during recovery.

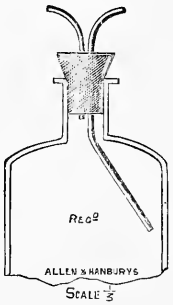

Fig. 11.—The Author's Ether Bottle Stopper for Use with an Ordinary Eight-Ounce Dispensing Bottle.

This is interchangeable, and may be used with any ordinary medicine or stock bottle for the open ether method. The tube within the bottle is intended to be bent at an angle, and should *not* be straightened. The stopper answers equally well for chloroform and the anæsthetic mixtures.

2. When the patient is in position for the ether administration, a small mouth-prop is inserted between the side teeth and held in position by light pressure upwards upon the lower jaw with the administrator's left hand.

3. A ring-pad made of gauze is then rested on the patient's face encircling the nose and mouth.

4. The wire mask fitted with a pad made of sixteen layers of gauze is now laid upon the ring-pad,

and the patient instructed to breathe in and out slowly through the mouth.

5. The administrator now talks quietly to the patient all the time, while he drops ether continuously upon the mask until unconsciousness supervenes.

6. The mouth is then opened wider with a jaw gag, a tongue clip with finger loop is inserted, and the tongue drawn slightly forward away from the pharynx.

The mouth-prop is then readjusted, leaving the mouth partly open as at first. The ring-pad and mask are then replaced and the ether drops continued.

By means of this procedure all further anxiety as to the patency of the airways is removed, and laboured respiration entirely avoided.

The taste of ether when presented in this manner is not objected to by the majority of patients, because it is too weak to be pungent. There is hardly any excitement or struggling except in alcoholic subjects, for whom it should not be used. The only movement which may usually be anticipated is a tendency to slowly raise the head and sit up, which is often witnessed also during the induction with C_2E_3 mixture in adults. This need not be restrained, as it only lasts for a minute or so; and if the ether be steadily continued the patient will slowly sink back upon the pillows in the third stage of anæsthesia. The time taken to induce this condition is, on the average, between six and seven minutes. As a rule, when slight stertor begins to arise, the anæsthetist's troubles are over, but movement of the patient by commencing to wheel the couch along or to prepare the abdomen for operation at this moment is apt to induce vomiting,

so that the ether should be continued a little longer before doing either.

TYPE OF ANÆSTHESIA.—The remarkable difference in the type of anæsthesia when compared with that of the closed-bag method is now apparent. The amount of mucus secreted in the mouth and fauces, trachea, and bronchi, is generally much less. There seems to be no tendency to coughing, retching, or laboured breathing. The depth of respiration is decidedly less in degree, and sudden changes in its type are rare. The colour of the face is pink, unless surgical shock or hæmorrhage take place. The pulse rate is, as a rule, about 80 to the minute, and its volume full, whilst the blood-pressure is well maintained.

There is no oozing of venous blood from the operation wound nor congestion of the capillary vessels. The musculature becomes completely relaxed, and reflex laryngeal spasm and disturbances of respiration caused by surgical stimuli are less marked than under any other anæsthetic. Abdominal movement is not heaving in character.

AFTER-EFFECTS.—Experience shows that after-sickness and other bad effects, such as headache and taste of ether, are remarkably reduced, the patient being frequently quite undisturbed by any such sensations. This is corroborated by Drs. Weland and Osgood, of Boston, Mass., who, writing on "gauze-ether,"[1] state that the occurrence of post-anæsthetic vomiting is reduced to $32\frac{1}{2}$ per cent., and transient acetonuria to 26 per cent., of the cases. Profuse perspiration occurs in many patients both during and after operation, and therefore, besides blanket clothing,

[1] "Annals of Surgery," part 177, p. 460.

the temperature of the operating-room and bedroom should be maintained above 60° F. The author finds by experiment that the temperature of the air within the mask does not sink below 70° F.

A few details may now be given from the experience of Miss Alice Magaw, anæsthetist to Dr. W. J. Mayo, at St. Mary's Hospital, Rochester, Minn., which are recounted by her in "A Review of Over 14,000 Surgical Anæsthesias"[1]:

"A much deeper narcosis is required to start an operation or to make the incision than later on, when the operation is in progress."

"Never bid a patient to 'breathe deep,' for in so doing a feeling of suffocation is sure to follow, and the patient is also apt to struggle."

"During the operation, as soon as the patient begins to get control of the jaw, more complete narcosis is required."

"Formerly operations for exophthalmic goitre were looked upon with a great deal of dread on account of the anæsthetic. We have found these cases, when properly managed and the ether given by the drop method, were as good subjects as any other class of cases of the same gravity."

"One-sixth of a grain of morphine and $\frac{1}{120}$ grain of atropine are administered to avoid tracheal mucus thirty minutes before operation."

The mask and gauze can be boiled, and the latter used again for further cases if desired. Instead of a gauze face-pad, the author experimented with a rubber rim to the open mask, but discovered that

[1] "Surgery, Gynæcology, and Obstetrics," vol. iii., No. 6, pp. 795–799, December, 1906.

its perfect fitting, after the lapse of some minutes, produced the laboured breathing which is seen with the bag inhaler. This does not occur with a loose gauze pad, which forms sufficient protection from the undue escape of the heavy ether vapour.

After anæsthesia has been established, in order to maintain it with ether during operations upon the mouth and tongue, the tubes of Crile's nasal ether

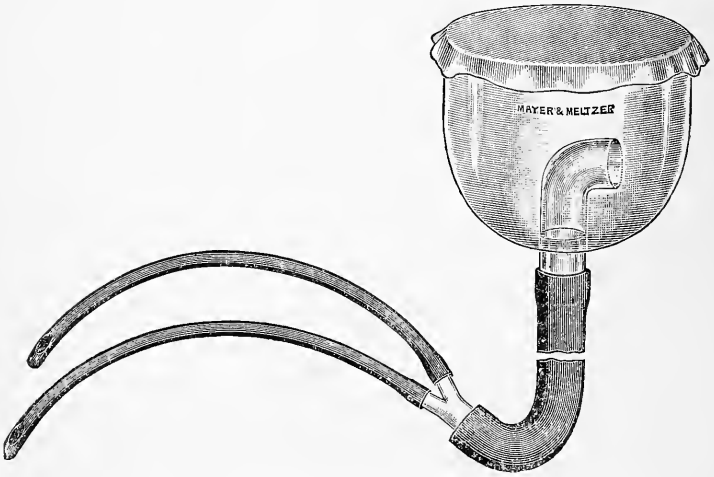

Fig. 12.—Crile's Nasal Ether Apparatus.

apparatus may be passed through the nares down to the level of the superior aperture of the larynx; gauze must then be packed into the pharynx and the air-way thus shut off from danger of invasion by blood and débris. Ether is poured upon the domette covering of the glass funnel through which the patient is then breathing.

One drawback to the use of the open method is the quantity of ether which passes into the atmosphere;

but the amount used is much reduced after a little experience, when with more faith less ether is found to be necessary. The difference of the method does not reduce the danger of the occurrence of acute bronchitis and pneumonia in patients with catarrh, chronic bronchitis, or emphysema, for whom ether is unsuitable; nor should it be continued if mucous râles become audible during operations which, by reason of after-pain, will prevent the patient from coughing to clear out the bronchi, such as those upon the stomach and gall-bladder. Bronchitics, alcoholics, malarial subjects, and those with a family history of insanity, take chloroform better than ether, and will prove unsuitable patients for this method.

The open mask may be used after anæsthesia has been induced with nitrous oxide and ether or the C_2E_3 mixture, if preferred; but the simplicity, asepsis, and perfection, of the method *ab initio* leave little to be desired.

THE CLOSED METHOD.—In the year 1903 the author devised a regulating inhaler for the administration of ether alone, nitrous oxide and ether, or ethyl chloride and ether, which has proved to be very portable and easily managed. Its breathing channels are of wide calibre in order to obviate the possibility of mechanical obstruction within the apparatus, and the anæsthesia produced is like that obtained with an Ormsby inhaler, with the added advantage of accurate control of the strength of vapour presented to the patient.

The ether is poured upon a sponge within the inhaling bag, and when this has been attached to the

regulator before the administration there is no smell of ether in the air-channels, because they are completely shut off from the evaporating liquid.

DIRECTIONS FOR USE WITH ETHER ALONE.—There are two ways in which this inhaler can be used for the induction of ether anæsthesia, the second

Fig. 13.—The Author's Regulating Inhaler for Ether.

method being the better one, as it is more rapid, and struggling is avoided. In the *first* method—

1. Remove the ether bag from the regulator by detaching the collar, and place a honeycomb sponge the size of an orange (which has been freshly squeezed

out from warm water) in the sponge cage of the bag, so that it does not project upward into the lumen of the collar.

2. Pour $1\frac{1}{2}$ ounces of liquid ether upon the sponge, attach the collar to the regulator, and turn the handle "off."

3. Fit a face-piece of suitable size to the proximal end of the regulator. Face-pieces will not fit the distal end, so that there can be no mistake as to the proper end. It is well to use the smallest face-piece which will conveniently cover the nose and mouth of the particular patient from the bony bridge of the nose to the root of the lower lip, because there is less air

Fig. 14.—The Author's Aluminium Surgical Mouth-Props.

leakage, which tends to imperfect anæsthesia, than with a large face-piece.

4. Insert a surgical mouth-prop between the teeth.

5. If the patient be lying down, the face-piece should be fixed on to the regulator at a right angle to the vertical plane of the apparatus, and it can now be firmly and carefully applied to the patient's face after the head has been gently turned to the side for that purpose.

6. Instruct the patient to breathe in and out steadily, but not forcibly, through the mouth, encouraging him verbally from time to time as the regulator handle is *very* slowly turned on, say $\frac{1}{10}$ inch at each expiration.

Holding of the breath or coughing before the regulator is fully on means that the vapour admitted is too strong, and it must then be weakened by turning the handle back a little and proceeding again more slowly. By this method the patient at first breathes pure air, then air mixed with ether, and *finally* rebreathes into the bag.

In the *second* manner of using the inhaler, an empty bag, such as a Clover's or that for ethyl chloride, of the same size as the one containing the ether sponge, is attached by an angle-piece to the distal side of the regulator.

The ether sponge being charged as before, the handle turned "off," and a mouth-prop inserted, the patient is allowed to rebreathe five times into the empty bag filled only with his own expirations, and the regulator handle is then slowly turned on.

By this method the patient *rebreathes* first into the empty bag, then ether vapour partly into both bags, and finally into the ether bag only. When the handle is turned fully on, the empty bag is detached and laid aside. This produces much quicker anæsthesia, as the ether-laden expirations are not lost, and the contained air is warmer than the tidal inspirations from the atmosphere in the first manner of use.

DIRECTIONS FOR USE WITH NITROUS OXIDE AND ETHER.—Prepare the apparatus as for ether alone, first method, and insert a surgical mouth-prop between the teeth. Then fill a gas-bag nearly full, but not distended, with nitrous oxide gas, attach its stopcock to the distal end of the ether regulator, and apply the face-piece.

The patient is now instructed to blow freely, but not forcibly, through the apparatus at each expiration, and after he has begun to do so regularly the gas is turned on. Five breaths of gas are now exhaled into the air, and then the gas-valves are turned out

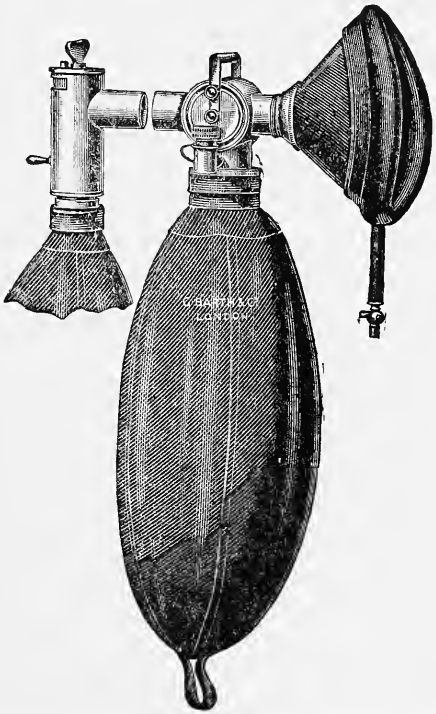

FIG. 15.—THE AUTHOR'S REGULATING ETHER INHALER, WITH SIR F. HEWITT'S NITROUS OXIDE GAS-BAG AND STOPCOCK FOR ATTACHMENT.

of action, and rebreathing into the gas-bag is thus commenced. Now the handle of the ether regulator is to be slowly drawn towards the marks 1, 2, 3, 4 (thereby disclosing the orifice of the ether-bag and closing that of the gas-bag). This movement should be

continuous—unless cough should arise, when a pause may be made—but slow, because the full strength of ether vapour is yielded by a quarter-circle turn.

When the handle has arrived at mark 4, the gas-bag is to be detached and laid aside. A breath of air may subsequently be given either by turning the handle back for an inspiration or by lifting the face-piece *at every fifth breath.*

After seven or eight minutes more ether should be added *through the face-piece or filler* by pouring in an ounce of the liquid and shaking it down upon the sponge, and this should be repeated at intervals of ten minutes throughout the operation.

By this method the patient inspires five breaths of gas, which are exhaled into the atmosphere; he then rebreathes into the gas-bag, then partly into both bags, and finally into the ether-bag alone.

DIRECTIONS FOR USE WITH ETHYL CHLORIDE AND ETHER.—1. Prepare the ether inhaler as for ether alone, first method, and insert a surgical mouth-prop between the teeth.

2. Pour 2, 3, or 4 c.c. of ethyl chloride, according to the type of patient, into the glass tube, and attach this to the tap at the bottom of the ethyl chloride bag, and fix the latter on to the ether regulator by its angle-piece.

3. Apply the face-piece, instruct the patient to breathe slowly through the mouth, and quite fill the ethyl chloride bag with air; elevate the glass tube so that the ethyl chloride gradually runs into the bag.

After five respirations gradually turn on the ether. This may be done more rapidly than with ether vapour alone or with nitrous oxide, because ethyl

chloride more quickly abolishes the coughing reflex; but, as it is also far more potent, the corneal reflex must be carefully tested at this stage, and air admitted immediately should it grow weak or disappear.

Ethyl chloride and ether in sequence is the most rapid and tranquil manner of inducing ether anæsthesia in powerful and resistant types of subject, but.

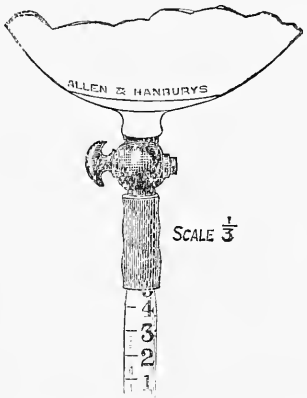

Fig. 16.—Tube for Ethyl Chloride attached to Bottom of a Second Bag.

owing to the early abolition of the reflexes by ethyl chloride, is decidedly more dangerous than the other methods described.

CLOVER'S INHALER.—The objection to the use of the ordinary Clover's ether apparatus, in the author's experience, has been the restricted size of its air-channels and the comparatively weak anæsthetic effect which it produces without an undue limitation of the air-supply, which renders the patient dusky in colour and produces venous oozing of blood in the field of operation.

Sir F. Hewitt has had a wide-bore Clover's inhaler constructed, with the object of overcoming these objections.

A Clover's portable ether inhaler should be constructed in such a manner that no feeling of dyspnœa is perceptible when it is breathed into with the indicator either at 0, 1, 2, 3, or 4.

The fit of the face-piece is the next most necessary consideration. It will very seldom be necessary to

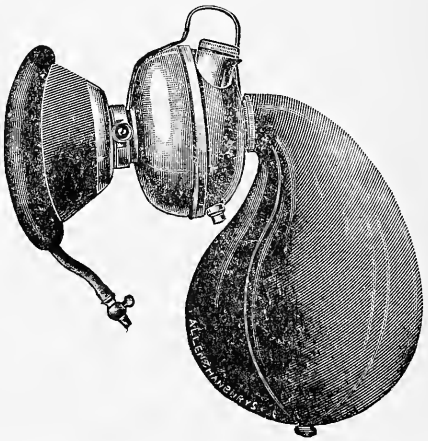

Fig. 17.—Hewitt's Wide-Bore Clover's Ether Inhaler.

use a large face-piece (except in dental cases with the mouth propped widely open). Two face-pieces, one of medium size, and another very small one, for children and young people, should be procured. The use of these will produce a much greater success in the ordinary run of cases, owing to leakage of air under the rim of a large one interfering with profound anæsthesia.

The ether chamber itself holds $1\frac{1}{2}$ ounces of ether, and its orifice should have a stopper fitted with a

little glass bulb, so that the amount of contained ether can be estimated at any time if the instrument be held vertical.

Next to the ether chamber is a closed tank containing water, which latter can be heard splashing inside if the instrument be shaken; this sound is, therefore, no indication that the inhaler contains ether, as, it seems, is often erroneously supposed.

Whenever the atmosphere is at all cool in the operating-room, the water-tank of the inhaler should be immersed in warm water (about 80° F.) for a minute or two before use; this will cause the ether, which is afterwards poured in, to evaporate more evenly than if the inhaler be left cold.

The proper-sized face-piece is then chosen and securely fixed on to the shaft of the ether inhaler; otherwise it may revolve without working the apparatus.

To fill the ether chamber, it will be found best to turn the indicator towards the mark 1, as the liquid ether passes in more readily when air can escape from the internal slots partly opened by this movement.

Twelve drachms of ether having been introduced, the inhaler should be held in the hand most convenient to the administrator and for the purposes of the operation. Supposing, for instance, the left breast is to be excised, the patient's face should be turned to the right, and the metal hemisphere should lie in the palm of the anæsthetist's right hand. The warmth of the hand is of use in maintaining the ether at a proper temperature, and the finest movements in regulating the strength of ether vapour can be made by the fingers and thumb upon the revolving

hemisphere. A surgical mouth-prop is now to be inserted between the side teeth.

Next the anæsthetist, making quite sure that there is no smell of ether in the face-piece, should adjust the latter to cover the patient's nose and mouth. Turning the head well to the side, the third and fourth fingers of his left hand should lie below the patient's chin, his first and second fingers supporting the face-piece against the lower cheek, whilst his thumb compresses the face-piece against the upper cheek. In this way the slightest swallowing movements, and any alteration in the respiratory rhythm, can be appreciated by the little fingers, which also, during anæsthesia, elevate the chin to prevent the tongue falling back against the pharyngeal wall.

The patient is now asked to breathe slowly "in and out through the mouth," and, after a few reassuring remarks from the administrator, the inhaling bag may be adjusted and filled nearly full with the patient's expirations. This is done by raising the face-piece slightly (at its lower end only, during inspiration, and lowering it again during the next expiration. This little manœuvre can be easily practised by the student upon himself with an empty inhaler.

The face-piece is closely adjusted, and the bag now being nearly full, but not distended, the patient should breathe to and fro five times before any ether is admitted. The administrator now very gradually turns on the ether about $\frac{1}{16}$ inch at every expiration, proceeding steadily as long as the patient breathes quite freely, the slightest swallowing or holding of the breath being met by stopping the revolution, or

even turning back a little way to decrease the pungency of the vapour.

The respirations will gradually increase in depth and force, and the indicator generally can be worked up to $1\frac{1}{2}$ before any air need be admitted; but when required by any cyanotic appearances, air should be given during an inspiration, the following expira-

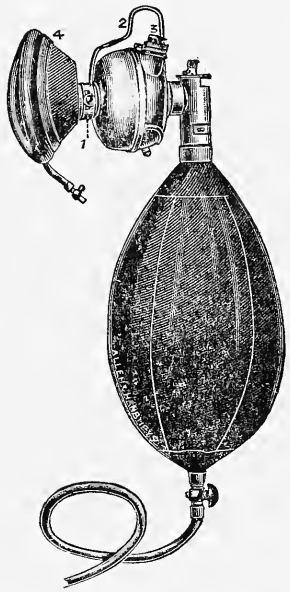

Fig. 18.—Hewitt's Large-Bore Ether Inhaler, with Gas-Bag attached.

tion being caught by the administrator in the inhaling bag. Proceeding gradually in the same way, when slight stertor is heard, a breath of air at every fifth inspiration may be given, and also throughout the subsequent administration. If the patient's head be kept on the side throughout, mucus which is secreted does not run back into the fauces and cause cough

and other straining movements, and the anæsthetist, keeping his wrist and arm upon the upper side of the patient's head, can, by pressing downwards, also effectually control efforts at movement on the part of any restless subject during the second or "excitement" stage.

It should never be anticipated that any patient will be properly flaccid or beyond the possibility of reflex movement until the lapse of at least five minutes from the first breath of ether, nor, on the other hand, should the induction take more than ten minutes at the longest.

Surgical anæsthesia with good colour, deep, regular respiration, and a weakly active lid reflex, should be attained within about five to seven minutes; otherwise the second stage (in which excitement, swallowing, vomiting, coughing, rigidity, holding of the breath, and all sorts of difficulties may occur) is prolonged, with no possible benefit to patient or surgeon.

No patient should be allowed to vomit at all in passing into anæsthesia. It is a sign of too little anæsthetic having been given, and can always be avoided by skilfully and gradually increasing the strength of the vapour.

The most common mistake made by all unpractised administrators is to neglect to make the face-piece fit absolutely, to the exclusion of air; but this must be done except at every fifth breath, which it is intended should be taken from the atmosphere.

The first $1\frac{1}{2}$ ounces of ether will, as a rule, last for the first ten minutes of anæsthesia, but the quantity expended depends largely on the type and size

of the patient. The more bulky and plethoric the subject, the greater will be the dose of ether required to attain complete anæsthesia. Whilst a small woman may be kept completely under, perhaps, for ten or fifteen minutes with the first-mentioned quantity, a full-sized man may even require another ounce of ether poured in before he is ready for operation. When fresh ether is added the indicator should be put back to nearly 0, in order to prevent the coughing which might be set up by a sudden strong vapour of ether. It will also be found of advantage, whenever the inhaler has been removed, to carefully readjust the face-piece during an expiration, in order to refill the bag and partly warm the contained vapour before it is inspired.

The appearance presented by a patient when under the influence of ether by closed methods, and the respiratory sounds which he makes, differ considerably from those produced by chloroform and the C_2E_3 mixture.

The face is generally flushed, and the breathing deep and somewhat moist and stertorous, for owing to the strong circulation and the fulness of the vessels in the mucous lining of the air-passages, these tend to become swollen, especially in the upper respiratory tract, where the tongue, fauces, and tonsils, impinge upon the airway.

What has been said concerning the general prevalence of partial nasal obstruction applies with most importance to the use of ether, and necessitates the preliminary use of a mouth-prop before the administration by closed methods.

The corneal reflex may be allowed to become weaker

than is safe with chloroform, and the pupil is often moderately dilated owing to an inevitable anoxæmic element due to the rebreathing of expired air.

The mucous secretion in the mouth is sometimes very profuse and stringy, and may be drained away by the capillary action of a strand of gauze hanging out of the mouth from the cavity of the lower cheek.

Closed ether administration is unsuitable for patients with pulmonary disease and bronchitis, and also for persons of stout and very florid aspect, who become alarmingly cyanosed when subjected to air limitation or bronchial irritation.

It is well borne by the majority of patients undergoing rectal and gynæcological operations, provided its use be not persisted in when bronchial râles have become pronounced.

ETHER INFUSION ANÆSTHESIA.—This method of producing general anæsthesia was introduced in London by Dr. Felix Rood. He devised the apparatus and technique for its administration and gave the following account of it in 1912.[1]

The Apparatus consists of an upper reservoir to contain a supply of the solution. This reservoir is connected by a rubber tube to a regulating chamber. This chamber, besides acting as a regulator, also acts as an indicator. And, although the stream of fluid is interrupted so that its rate of flow can be seen, the pressure at the same time is not interrupted, but is transmitted continuously by the cushion of air contained above the fluid in the regulating chamber.

[1] Proceedings of the Royal Society of Medicine, Section of Anæsthetics, March 1, 1912.

The fluid then passes from the regulating chamber to the warming chamber, and so on to the cannula.

The Solution.—Ether is soluble in normal solution to the extent of 10·8 per cent. by volume. In the first few cases of this series a 10 per cent. solution of ether—that is, 2 ounces of ether to the pint of saline—was used. It was found that with this concentration a transient hæmoglobinuria occurred. This was usually present in the first specimen of urine passed after the operation, and not afterwards. On account of this a 5 per cent. solution, 1 ounce to the pint, was tried. No hæmoglobinuria followed. In order to be still more certain that there was no blood destruction, a number of specimens of the blood were taken at intervals throughout several administrations. These were examined microscopically, and a count of the red corpuscles made—this showed no hæmolysis. Finally, the 5 per cent. ether solution was mixed with blood and examined, both in a test-tube and microscopically, this also showing no laking. I think that these are sufficient grounds for assuming that there is no blood destruction. Later experiments on the same lines with a solution containing $1\frac{1}{2}$ ounces of ether to the pint of saline showed that this concentration was equally free from risk.

TECHNIQUE OF INDUCTION.—The saline solution is prepared in flasks, in which it is boiled; the neck of the flask is then plugged with sterile gauze, and the solution allowed to cool. Shortly before required the ether is poured into the cold sterile saline. The flask is then well shaken ; the solution becomes opaque for a moment, then gets quite clear; it is obvious that the ether is completely dissolved. The

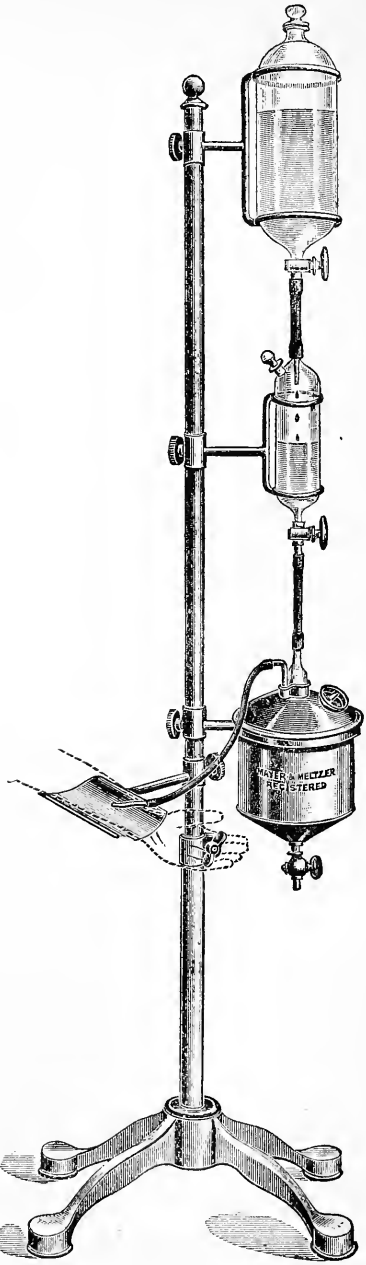

FIG. 19.—ROOD'S ETHER INFUSION APPARATUS.

whole apparatus is boiled previous to use. It is then fitted to the stand and filled with the ether solution.

The patient is prepared for the anæsthetic in the ordinary way—also a hypodermic injection of atropine, atropine and morphia, or atropine, morphia, and scopolamine. The exact dose and combination given depend, of course, on the age and condition of the patient, and also upon the pathological conditions present. The next step is to introduce the cannula into the vein. The most convenient vein is either the median basilic or the cephalic—in the arm. It requires so much greater pressure to make the solution flow in the veins of the leg that it is hardly possible to use them. The skin of the arm is prepared. A solution of iodine in ethylene dichloride is a very convenient method. A little eucaine solution is injected, the vein exposed, and the cannula tied in. For this part of the administration it is absolutely necessary to have an assistant, as the taps of the apparatus have to be manipulated at a time when the administrator is occupied in tying the cannula into the vein, a proceeding that requires the strictest asepsis, as a wound of this character left exposed so long and irritated by the presence of the cannula is peculiarly liable to go septic, which may be followed by the gravest possible consequences. When the cannula is fixed into the vein, the solution is at first allowed to flow in rapidly, the regulating tap being turned full on. Induction of anæsthesia is usually quite smooth and rapid, three or four minutes being the average time. Struggling during induction is rare, and if it does occur is easily controlled, as one is not dependent upon respiration for the introduc-

tion of the drug. The ordinary signs of anæsthesia, of course, occur—automatic respiration, muscular relaxation, and abolition of reflexes. As soon as smooth anæsthesia is established, a little experiment will enable one to arrive at the minimum amount required, and the apparatus can be set to deliver this amount. Of course, during a long operation this can be gradually reduced. The noticeable features of the anæsthesia are regularity and smoothness, also the ease with which it can be graduated and the great rapidity with which patients respond to slight alterations in dosage.

The most striking advantages of the method are seen in those cases where the patient is in a condition of extreme inanimation—viz., cases of abdominal malignant disease. These patients often leave the table in a much better state than they were before. So that in any case in which the patient is likely to be benefited by saline infusion—either as a means of relieving shock or hæmorrhage, or because shock is expected—this method has given excellent results. Similarly, the results have been good with acute abdominal conditions generally, and especially so in cases of ruptured gastric or duodenal ulcer.

A degree of relaxation of the abdominal wall quite equal to that produced by any other anæsthetic, excepting stovaine, can be obtained by this method. It frequently happens with the inhalation method of administration that although it is otherwise indicated, ether cannot be given because some form of pulmonary disease exists; the infusion method is very useful in these cases, and can be given without risk of irritation. Then there is that large class of cases

involving operations upon the mouth and jaws. Many of these cases involve long and extensive dissections associated with much shock. It is therefore a distinct advantage to be able to substitute ether for chloroform with equally good results. The saline infusion is also beneficial, as these proceedings often involve considerable loss of blood. And also, even in minor operations of this type, the separation of the spheres of activity of the surgeon and anæsthetist cannot but make for comfort, convenience, and asepsis. In certain operations upon the throat and nose a more or less vertical posture is essential; under these conditions a smooth, even narcosis can be obtained with this method without congestion or danger of syncope.

ANÆSTHESIA BY THE INTRATRACHEAL INSUFFLATION OF ETHER. — Dr. Robert E. Kelly of Liverpool has described the method as follows :[1]

It is to Elsberg of New York that we owe the first apparatus for use on the human subject.

If we can supply a continuous stream of air under pressure at the lower end of the trachea, the diffusion of oxygen will go on without respiratory movements. A catheter about half the size of the glottis is passed down the trachea until it reaches the bifurcation. The catheter is connected with a forced draught of air from 10 to 40 mm. Hg pressure, the air having previously been warmed, moistened, and etherized. The excess of air escapes between the catheter and the glottis.

The patient having been anæsthetized in the ordinary way, the tracheal catheter is passed. This

[1] *British Medical Journal*, July 20, 1912.

is an ordinary coudé catheter of a size from 18 to 26 French. It should be half the diameter of the glottis, and for adult males a No. 22 is suitable.

This catheter is passed by direct laryngoscopy, a Chevalier Jackson's instrument, with distal illumination, being used. It is done in a few seconds. If the catheter is too soft a stylet makes its introduction easy. On the catheter are two marks, 12 and 26 cm. from the tip, for it has been found that these distances are the usual distances to the glottis and bifurcation of the trachea respectively from the incisor teeth. As a rule the distance to the glottis is just about half that to the bifurcation, so that if the distance to the glottis is noted the catheter must be passed just as much again in order that its tip should be in the right place. In order to prevent the catheter from being bitten, it must be protected by a "bit." I have found a Smith's gag without the tongue depressor very useful for this purpose, and to prevent the catheter from being coughed out it is attached to this gag by a small bulldog forceps which does not compress its lumen. The catheter is now connected with the current of air and the ether turned on.

The reflex of breathing still goes on, but the movements are light. In deep anæsthesia they are sometimes very light; still, the internal respiration goes on, and the patient's colour remains a healthy pink. The depth of the anæsthesia is judged by the corneal reflex and the reaction to light.

As soon as the operation is finished pure air is turned on, and the ether, so to speak, flushed out. This flushing with air is said by most observers to

make the recovery-time from anæsthesia very short, and in some of our cases the patients were able to talk rationally within half an hour after the end of the operation.

If there is any cyanosis it means that the catheter is too large, and this is generally also shown by the fact that the manometer reading is too high. A smaller tube will suffice to put this right. As a rule the manometer reading should be from 10 to 40 mm. Hg. This pressure, of course, should not be absolutely continuous, for this would lead to embarrassment of the heart by not allowing the respiratory pump action on the venous circulation in the thorax, so the anæsthetist three or four times a minute allows the pressure to drop to zero by opening the tap.

Dr. Francis E. Shipway advocates intratracheal insufflation of ether in thoracic surgery, for preventing collapse of lung; in surgery of the mouth, nose, and pharynx, and in cases of intestinal obstruction with vomiting, for preventing inspiration of blood, pus, vomit, etc.; in goitre cases, especially with obstruction, for providing a free airway and constant ventilation; in surgery of the head, neck, and spine, the anæsthetist being well away from the surgeon, and difficulties of administration being overcome; for operations on the upper abdomen, the respiratory movements being much lessened; for artificial respiration, *e.g.*, in cases of morphine-poisoning; and has invented the apparatus shown in Fig. 20 for its employment.

This can be used either with a foot-pump or with an electric motor and pump. The former is provided with an air-filter, which serves the double purpose of freeing the air from dust, etc., and of

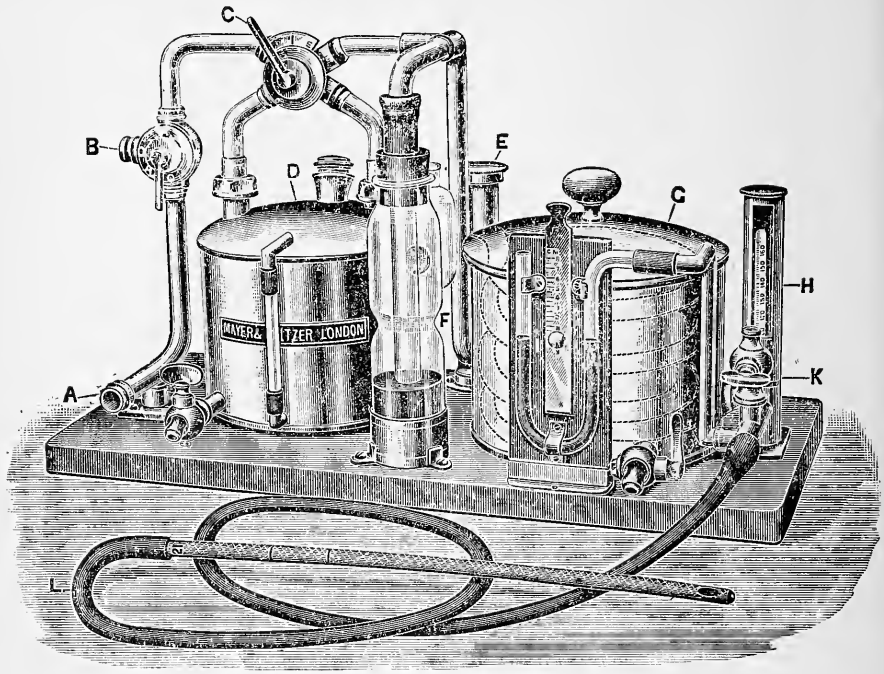

Fig. 20.—Shipway's Apparatus for Intratracheal Insufflation of Ether.

A, Air inlet for connection with foot-pump or rotary motor pump.

B, Tap for connection with oxygen cylinder. Lever at A, air only; at O, oxygen only; at AO, oxygen and air.

C, Ether regulating tap.

D, Metal ether chamber, easily detached for cleaning, fitted with gauge, filling aperture, and emptying tap.

E, Moistening chamber, to hold glass tube with moist gauze wick. Tube to be half filled with water.

F, Mercury safety valve, blows off at 20 mm.

G, Warming chamber, with lid and emptying tap.

H, Thermometer. Reading should stand at 120° F. in order to give a temperature of 98°–99° F. at end of tubing.

I, Mercury manometer. The scale is slightly adjustable.

K, Tap for reducing the volume of air-stream at intervals.

L, Tubing and intratracheal catheter.

converting the intermittent air-stream into a constant one. The foot-pump does not give such a regular

anæsthesia as a mechanical device such as a motor, and entails rather hard work upon the anæsthetist during a long operation, but it is a very fair substi-

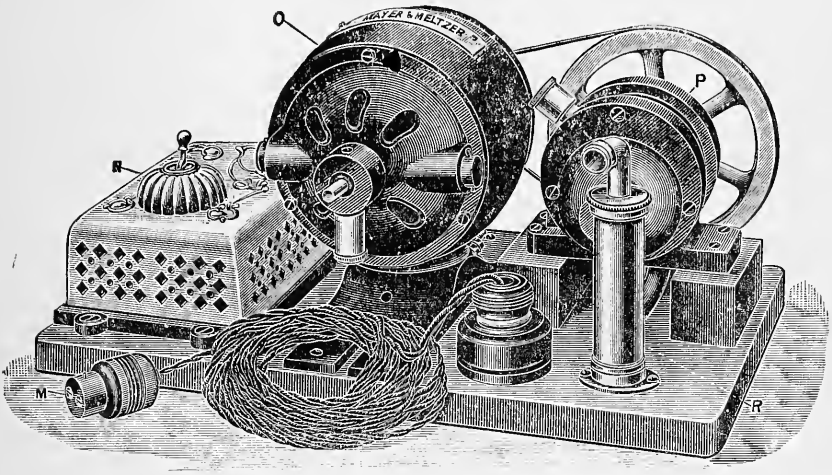

Fig. 21.—Rotary Electric Pump for Supplying Air to the Ether Insufflation Apparatus.

M, Connecting plug and cable for connecting motor to electric main.

N, Regulating switch for accommodating speed of motor.

O, Motor of suitable voltage to work from electric main for driving pump.

P, Rotary pump giving a continuous air blast.

R, Filter for air to be packed with gauze to which tubing is attached to carry air to the ether apparatus.

tute. Where the motor is used, a foot-pump should always be at hand in the rare event of a failure of the electric current.

CHAPTER XI

CHLOROFORM

Chloroform ($CHCl_3$) is a heavy, colourless, transparent liquid of sweet, pungent taste and agreeable odour, which boils between 140·2° and 141·8° F. The density of its vapour is nearly 4·2 as compared with air at 1.

A small addition of alcohol or slaked lime to chloroform prevents its decomposition; exposure to air and sunlight, however, will lead to the formation of carbonyl chloride ($COCl_2$), which is irritating and irrespirable. The rapid splitting up of chloroform vapour into carbonyl chloride and hydrochloric acid so commonly occurs in the presence of any open flame, that open gas-burners, stoves without flues, and sterilizers, should not be used in small unventilated rooms where chloroform is being administered, severe choking cough being induced among the operators and nurses, and sometimes in the patient, by these highly poisonous products. It is stated, also, that bronchitis or broncho-pneumonia may follow after their inhalation.

Liquid chloroform is decidedly caustic in its action upon the skin; it must not, therefore, nor mixtures containing it, be allowed to drop upon a patient's eyes, face, lips, neck, or shoulders, during administration. The contact of masks and towels wet with

it may produce redness and vesication, persisting subsequently for several weeks.

PHYSIOLOGICAL ACTION.—When inhaled in quantities representing from 1 to 3 per cent. of the inspired air, chloroform vapour produces a transient initial rise of blood-pressure, followed by a considerable fall below the normal. Experiments upon animals by many observers have not satisfactorily proved to what primary factor this fall of blood-pressure is due—*i.e.*, whether to paralytic effect upon the cardiac muscle or nervous mechanism, or upon the vascular musculature, or the centre controlling the vasomotor system. That in deep anæsthesia the fall always takes place, and that in this condition the influence of gravity has a considerable effect upon the cerebral blood-supply, was first pointed out by Leonard Hill, and is a well-established fact.

When the feet are raised, the cerebral centres become filled with blood, and when the head is raised these centres are to a certain degree emptied, and their activities decreased.

The pulse under chloroform falls in frequency to about 64 per minute, though as a rule its volume is well maintained.

The respiration under chloroform is not so deep and vigorous as under ether, and mucus is not secreted by the lining membranes of the air-passages to any marked extent.

The colour of the face under chloroform is at first a little heightened, but as narcosis proceeds is apt to become paler with the general fall of blood-pressure.

The corneal lid reflex obeys the same laws as under ether, gradually diminishing in activity as anæsthesia

deepens, but under chloroform should never be allowed to disappear entirely. The pupil also presents the same phenomena, but dilatation with a weakly active corneal reflex means the approach of too profound a degree of anæsthesia. Chloroform should be administered in the supine or lateral positions for preference, all positions in which the head is considerably raised tending to accentuate the fall of blood-pressure and the cerebral anæmia described above.

The methods of administering chloroform are—(1) *The open method* of pouring the liquid upon the corner of a towel, or upon one layer of lint or flannel stretched over a wire frame. Varieties of this latter are Esmarch's, Skinner's, and Schimmelbusch's masks, which are to be held near the patient's face; or (2) by means of *inhalers* with accurately fitting face-pieces for the delivery of fixed percentages of the vapour, such as Vernon Harcourt's and Levy's apparatus.[1]

The fact that complicated apparatus distracts the administrator's attention from the condition of the patient, and the more important one, in the author's experience, that intercurrent anoxæmic factors are less likely to be recognized when a face-piece is being employed, tend to annul the theoretical advantages which are claimed for these latter machines.

THE OPEN METHOD.—It is advisable to use a chloroform mask in all cases in preference to a loose piece of lint or towel-end, because the latter may come in contact with the patient's face and blister it when wet with the fluid anæsthetic.

Skinner's wire frame, covered with one thickness

[1] *Lancet*, May 27, 1905, p. 1413.

of ordinary flannel, is the best mask, and Thomas's 2 or 3 ounce chloroform drop-bottle should be procured for pouring the liquid upon it (Figs. 22 and 23).

In conducting the administration, it is a good plan to turn the patient's head to the right side, if this position be suitable for the operation, and rest your left arm lightly upon the left side of his head, with the palmar margin of your left hand and little finger supporting his lower jaw, the Skinner's mask (dry) being held between the other fingers and thumb of that hand, $\frac{1}{2}$ inch from the patient's face, so as to cover his nose and mouth. Now tell the patient to breathe

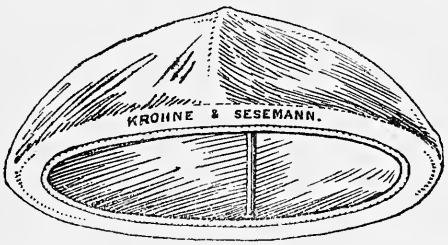

Fig. 22.—Skinner's Mask for Chloroform.

slowly "in and out through the mouth," or tell a child to close his eyes and "blow the scent away," and from the drop-bottle, held in your right hand, let fall a few drops of chloroform upon the outer and upper surface of the flannel mask opposite the patient's mouth, not near his eyes; then, very carefully watching its effect upon his respiration, continue dropping on chloroform until a patch of flannel about the size of a penny is wet with it. Stop adding chloroform for a few seconds whenever there is any holding of the breath, until respiration is again regular (Plate VI.).

Keep on telling the patient to "blow in and out," increasing the size of the wet patch to that of two pennies.

The patient's consciousness is now disordered; he is probably swallowing at intervals, and may attempt to move about. The best plan, therefore, is to bear slightly with your left arm and wrist upon the left side of his head, and thereby effectually prevent any

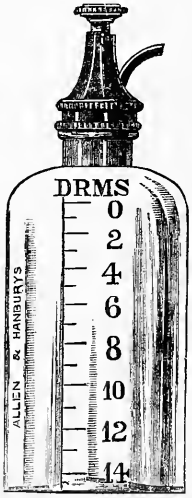

Fig. 23.—Thomas's Chloroform Drop-Bottle.

alteration in his posture. If an adult patient holds his breath or if a child cries at this stage, hold the mask away from his face for the very deep inspiration which immediately follows; then replace the mask and proceed as before, keeping a patch of the flannel always wet with chloroform. Regular automatic respiration with muscular flaccidity will soon supervene.

No patient should be sick in passing under the influence of chloroform, for if the vapour be gradually

and steadily increased, as indicated, the vomiting centre will be narcotized without giving time for nausea or retching to occur.

The patient should be ready for operation in six to eight minutes from the beginning of the inhalation—in no case longer.

When automatic respiration, in which expiration is quite free, and without hitch of any kind, is first heard, the patient's corneal reflex should be tested in order to discover the exact depth of anæsthesia.

It has been estimated by Dr. Waller[1] that a Skinner's mask used in this manner supplies a vapour of chloroform varying from 1 to 2 per cent. of the air

Fig. 24.—Boxwood Wedge for Separating Clenched Teeth.

inspired, and Mr. Legge-Symes's experiments[2] agree with this result, concluding also that, when the liquid is very freely applied, from 3 to 4 per cent. of chloroform vapour may be attained.

During the second stage of anæsthesia great care is needed in muscular and alcoholic subjects to prevent occlusion of the airways from jaw spasm. The passage of the index-finger along the patient's upper gums towards the molar teeth will often open an airway through the lips and over the tongue, which will prevent cyanosis from this cause.

Whilst the lid reflex is brisk, it must always be remembered that swallowing movements and crowing

[1] *Lancet*, July 9, 1904, p. 80. [2] *Ibid.*, p. 81.

respiration are frequently due to impending sickness. The anæsthesia must then be deepened by rubbing the lips to stimulate the breathing, and by adding more chloroform.

Pallor, sweating, and dilatation of the pupil, with a brisk corneal reflex, also indicate impending vomiting.

In many cases, owing to the falling back of the tongue at the commencement of stertor, tranquil anæsthesia cannot be obtained without pushing the mandible forward, and in some postures—*i.e.*, with the face to the ceiling—the tongue must also be drawn forward with the tongue clip to keep the airway clear.

In the surgical stage it is rare to find the eyes still mobile; but in certain subjects there is a tendency towards nystagmus, though, as a rule, this would indicate too light a degree of anæsthesia.

It is always dangerous to "push" chloroform inhalation in order to obtain greater muscular relaxation. Rigidity is often due to inadequate air-supply or the insufficient lapse of time for relaxation to supervene.

Having reached a proper degree of corneal reflex action, namely a weakly active upper eyelid, the administrator should state that relaxation may ensue in a few minutes, and then attend to the airway and posture in order to relieve any mechanical tension on the muscles. If rigidity persist, he should then try the effect of pushing "open ether" rather than chloroform, to which latter he can afterwards return.

Whenever the colour becomes pale and breathing shallow, the lips should be briskly rubbed and the face "dry-shaved" with a rough towel, which has a great effect in stimulating deeper respiration and

secondarily improving the circulation. Lowering of the head to refill the cerebral vessels has the same beneficial effect.

There is no doubt that in some persons chloroform requires some slightly stimulant adjuvant, and in those who remain pale and breathing feebly no time should be lost in changing to the C_2E_3 mixture or ether.

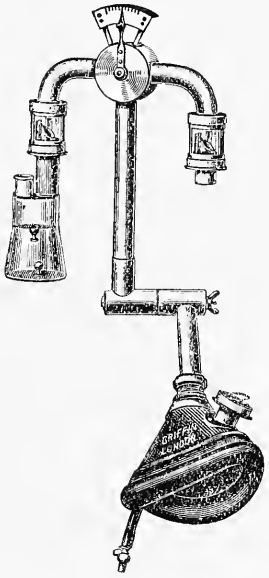

FIG. 25.—THE VERNON HARCOURT CHLOROFORM INHALER.

During operations, preventive measures, such as a change to ether inhalation, warmth, lowering of the head, and saline infusions, should be used to combat depression.

CHLOROFORM INHALERS.—The Vernon Harcourt inhaler provides, in sufficient quantity for full and free respiration, a mixture of air and chloroform which is automatically limited to a maximum strength

of 2 per cent., and can be diluted at will with additional air down to any smaller proportion.

The two-necked bottle is filled with chloroform to near the top of the conical part, and two coloured glass beads are dropped into the liquid to indicate when the temperature is within the range 13° to 15° C. If the temperature of the chloroform is below 13° C., both the coloured beads will float; if it is above 15° C., both will sink. In the former case the proportion of chloroform inhaled will be less than the pointer of the stopcock indicates; in the latter case it will be greater. During inhalation the chloroform is cooled by evaporation; its temperature may be kept between 13° and 15° C. by now and then holding the bottle in the hand till the blue bead has sunk and the red bead is beginning to sink.

The stopcock is so made that when the pointer is at the end of the arc nearest the bottle of chloroform the maximum quantity is being administered—namely, 2 per cent. When the pointer is at the opposite end only air will be inhaled, and when it is midway dilution of the 2 per cent. mixture with an equal volume of air will make the proportion 1 per cent. The shorter lines on either side indicate intermediate quantities—namely, 0·8, 0·6, 0·4, 0·2; and towards the chloroform bottle, 1·2, 1·4, 1·6, 1·8.

The valves on the two branches prevent the entrance into the apparatus of expired air, and also serve to show whether the stopcock is working rightly. Only one valve opens when the pointer is at either end of the scale, both equally when the pointer is midway, and for all other positions one valve opens more and the other less, in the degree indicated by the position

of the pointer on the scale. The movement of these valves shows also how full and regular the breathing is, and the slight click which they make conveys this information to the ears when the eyes are otherwise occupied.

It is generally found that beginning with the pointer at 0·2, and moving it on towards the chloroform bottle at the rate of one division about every half-minute up to 1·6 or 1·8, produces narcosis as quickly as is desirable.

For the maintenance of narcosis it is believed that 1 per cent., or even less, will be found sufficient. The stopcock can be moved by a touch of the finger, so as at once to increase or diminish the dose.

The face-piece, which is provided with an expiratory valve, and can be fixed in any position, is either attached directly to the inhaler, which in this case is held in the hand, and should be kept as nearly vertical and as steady as possible; or can be connected by about 20 inches of $\frac{1}{2}$-inch rubber tubing, the inhaler in this case being supported on a stand or hung on to the back of the bed.

The mask is made of solid toughened rubber, fitted with a rubber air-cushion. It can be washed or boiled, and, as it becomes plastic in hot water, the shape can easily be modified, if required, so as better to fit the patient's face.

The apparatus must be carefully examined to see that the parts are adjusted, and the administrator should inhale to see that the valves are working properly. About $1\frac{1}{2}$ ounces of chloroform should be poured into the conical bottle, and the beads seen to be floating. The face-mask should then be carefully applied. This is best done when the head is

turned to one side. Breathing taking place freely and the air inlet valve and expiry valve flapping properly, the inhaler should be grasped at the horizontal cross-piece with the right hand, while the lower jaw is pressed forward by the left hand placed behind the angle of the mandible. Firm pressure is necessary, as absolute co-adaptation of the mask to the patient's face is essential. If the pressure used is equal over the whole area of the face, the patient will not complain. It is a common fault to allow air to enter by the sides of the bridge of the nose. Absolute fitting of the face-piece having been secured, the strength of the vapour may be gradually increased by turning the pointer. This is done slowly, but, unless the patient is restless and struggles, not too slowly. Struggling is an indication for the lessening of the strength of the vapour, but not for removal of the face-piece, unless duskiness supervenes. When narcosis is attained, the usual signs being relied upon, in most cases the maintaining of anæsthesia can be effected with 1·5, 1, or even 0·5 per cent., according to the physique of the patient and the requirements of the operation. After prolonged administration slight duskiness may appear, and in this case the apparatus may be lifted for a few breaths and then replaced.[1]

THE JUNKER APPARATUS (Fig. 26), for the delivery of weak chloroform vapour by means of a bellows, which pumps air through liquid chloroform, was originally intended as a regulating inhaler for use with a face-piece; but its most valuable quality lies in the ease with which anæsthesia may be maintained by its means during air-passage operations

[1] Description issued by the makers of the apparatus.

with the face uncovered, either by the insertion of a tube terminal in the oral cavity or a catheter through the nose.

Its tubing is so small and the temperature of the liquid falls so readily during its evaporation that it is often much more difficult to keep the patient well under when the mouth is open than to overdose him.

There are, however, two points which it is of considerable service to remember during its employment:

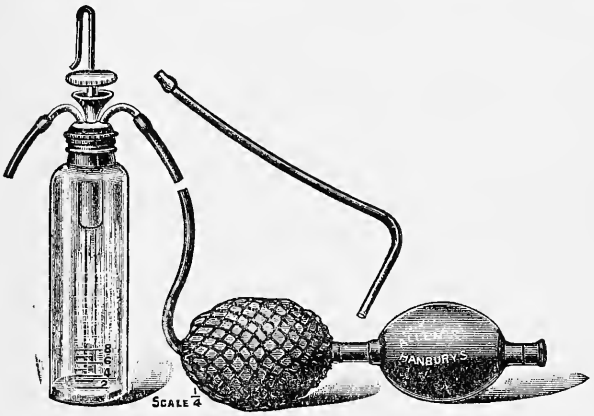

FIG. 26.—JUNKER'S CHLOROFORM BOTTLE.

The first is that the vapour of chloroform is four times heavier than air, and if the patient's face be towards the ceiling, the heavy chloroform sinks towards the air-passages, and is not so readily lost, remaining in the oral cavity like carbonic dioxide in the familiar beaker.

The second is that compression of the bellows timed for each inspiration can be made to deepen the effects of even a weak vapour by preventing its waste.

When a patient has been properly anæsthetized

by other means, and the third degree has been sustained for a few minutes, the vapour from Junker's apparatus will be sufficient to maintain this degree when skilfully manipulated; but it is rather a sorry weapon when employed in earlier stages upon an average male adult or those of alcoholic and athletic habits.

It is a good plan to have the bellows made so that they may be worked with the foot, leaving the administrator's hands free to steady the jaw-gag and tongue-clip, and to sponge the throat.

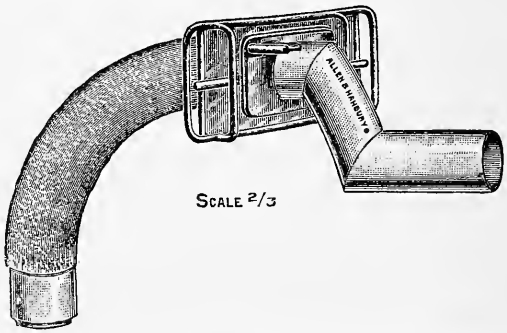

FIG. 27.—HAHN'S TRACHEAL TAMPON CANNULA.

A Junker's bottle after filling must *invariably* be tested before use, to insure the fact that vapour only, and not liquid chloroform, is issuing from the distal tube.

The bottle must be suspended from the coat lapel in such a way that it cannot become tilted, for several serious accidents have occurred from the liquid having been pumped into the patient's throat by mistake.

In cases requiring tracheotomy, anæsthesia having been previously induced with a Skinner's mask, Hahn's sponge-coated tracheotomy tube (Fig. 27) is

often inserted as a preliminary to the performance of thyrotomy and thyrectomy and kindred operations.

The terminal of a Junker's chloroform bottle can then be lodged just within, or held opposite to, the orifice of the Hahn's cannula, and anæsthesia maintained with ease. Care must be taken to clear the tracheotomy tube with a feather, and to allow the patient to cough occasionally should fluids pass the sponge from above the tube into the trachea below it.

Fig. 28 shows a blackened German-silver tube with

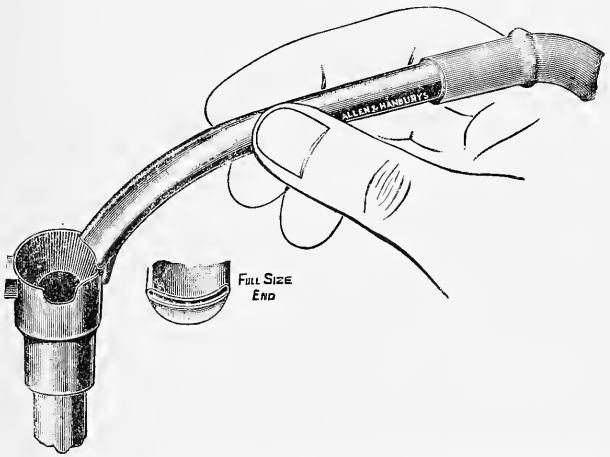

FIG. 28.—AUTHOR'S TUBE TERMINAL FOR BRONCHOSCOPE.

a flattened concave end, for the delivery of chloroform vapour from a Junker's bottle when Brüning's bronchoscope has been passed through the vocal cords into the trachea or one of the bronchi. By means of this chloroform tube terminal, which at its end is concentric with the orifices of the various portions of the specula of the bronchoscope, and has also a short

flange for steadying it in position, chloroform anæsthesia may be suitably maintained without interference with the surgeon's view from the eye-piece or the manipulation of instruments within the speculum. The blackened surface of nitric bronze does not reflect the light of the electric lamp, and is practically invisible through the instrument while in use.

CHAPTER XII

THE MIXTURE OF CHLOROFORM AND ETHER

A MIXTURE of one part of absolute alcohol, two parts of chloroform, and three parts of ether, by volume, was suggested by Dr. George Harley, and favourably reported upon by a committee of the Royal Medical and Chirurgical Society which sat in 1884. This, which is known as the ACE mixture, has been extensively used, and has proved to be nearly twice as safe as chloroform alone.

A freshly-made, well-shaken mixture of two parts of chloroform with three parts of ether, known as C_2E_3, is simpler and less expensive to prepare, and may be used on an open mask. For these reasons it may be now considered to be the best proportion to employ.

A large-sized Thomas's drop-bottle, made to hold 4 ounces of the mixture, is required.

For the administration the Skinner's mask is held firmly in the left hand. It is brought up to within $\frac{1}{2}$ inch of the patient's face. He is now told to breathe out slowly through the mouth, whilst the administrator pours $\frac{1}{2}$ drachm of mixture upon the mask. This may be repeated at the fifth breath, and after this $\frac{1}{2}$ drachm added every half-minute until the surgical degree of anæsthesia is obtained. Great care must be taken to prevent the liquid from dropping into the patient's eyes in pouring it upon the mask, and the moistened

edges of the mask from touching the patient's chin or cheeks, which will certainly be reddened and blistered if they do. As a protection, it is a good plan to rest the mask upon a clean towel laid upon the chin, which is then drawn along beneath the mask from time to time when it becomes moistened with the mixture.

To induce anæsthesia, the mixture may be used quite freely in the case of healthy adults, but the addition of small quantities at a time allows of the most even evaporation. The only tendency to excitement during the second stage of anæsthesia is usually shown by an attempt to sit up, which is almost characteristic of the mixture, and not often seen under chloroform alone. This movement need not be restrained, for after a few more breaths the patient will gradually sink back upon the pillows, and mildly stertorous breathing, ushering in the third or surgical degree, will supervene.

The colour and breathing are deeper than under chloroform, not so deep as under ether. The corneal reflex obeys the same laws; the pupil is of moderate size in the third degree, neither so small as the chloroform nor so large as the ether pupil. The circulation is decidedly more vigorous than under chloroform, and the pulse does not fall in frequency much below the normal.

The mixture causes very little secretion of mucus in the air-passages, and is exceedingly well suited to elderly patients undergoing severe operations, the subjects of morbus cordis, and also to children during the operation for the removal of enlarged tonsils and adenoids.

It forms a golden mean in the choice of an anæsthetic in all cases of doubt as to the most suitable for any particular case, and is a valuable routine anæsthetic for use by the general practitioner.

FIG. 1.—DORSAL POSTURE: HEAD TO SIDE, TO PREVENT FALLING BACK OF TONGUE OR DRAINAGE OF MUCUS TOWARDS FAUCES.
Anæsthetist holding Skinner's mask, and supporting patient's chin.

FIG. 2.—LATERAL POSTURE FOR RENAL OPERATIONS.
Carter Braine's arm-rest is shown, which allows full expansion of upper lung and fixes patient *in situ*.

To face page 160.

CHAPTER XIII

ETHYL CHLORIDE

Ethyl Chloride (C_2H_5Cl) is a colourless volatile liquid of spirituous chloroform-like odour. Its vapour is not quite so heavy as that of ether, being 2·2 as compared with air at 1. As the liquid boils at 12·5° C., it is now put up in sealed tubes containing 2, 3, or 5 c.c., which will keep indefinitely.

Two or three c.c. has been found to be a sufficient dose for children and small women, or for the purpose of preceding the administration of ether. Five c.c. is usually enough for an average adult male.

Ethyl chloride should never be administered without the preliminary insertion of a surgical or dental mouth-prop between the teeth, on account of the danger produced by occlusion of the airway when jaw spasm arises.

After a few breaths, when the vapour has been gradually admitted, a slight pleasurable exhilaration is experienced, and consciousness is then suddenly lost. Some involuntary struggling may take place, and then respiration suddenly becomes deep and stertorous; the colour deepens, the pupils dilate, all corneal reflex is lost, and the eyes are fixed, and frequently remain open. Cyanosis ensues if air be not then admitted. The pulse falls in frequency, but remains of fair volume if the administration be now discontinued. The time of the induction period is, on the average, fifty-one

seconds, and of available anæsthesia seventy-one seconds (McCardie).

The best results are obtainable by means of the apparatus shown in Fig. 29, which allows of a gradual addition of ethyl chloride vapour to a known volume of air breathed backwards and forwards.

Describing this apparatus in his "Clinical Observations on the Anæsthetic Effects of Methyl Oxide, Ethyl Chloride, and the So-called 'Somnoform,'" Sir F. Hewitt says: "The accompanying figure (Fig. 29) shows the arrangement of apparatus. By means of a hand bellows (A) of known capacity (the bellows shown holds 100 c.c. of air), 3,000 c.c. of air are pumped into the bag (B), the lower stopcock of which is then turned off. Five c.c. of ethyl chloride are now placed in the graduated glass tube (C), and the bellows having been detached from the lower stopcock of the bag, this tube with its ethyl chloride is attached to the stopcock. The face-piece having been accurately adjusted, the patient breathes air backwards and forwards through the air-slot of the upper stopcock, which contains no valves. The stopcock is now turned on, and to-and-fro breathing takes place into the bag. The tube with its charge of ethyl chloride is then gradually tilted, and the anæsthetic enters the bag, being gradually diffused into the air therein. There is no cough, holding the breath, or resistance, and anæsthesia is rapidly induced. In connection with this method, it may be pointed out that the face-piece, stopcock, and bag, can be readily washed in hot water, or, if preferred, in some antiseptic solution, such as 1 in 60 carbolic lotion, between each case —a procedure which is essential in all methods involving rebreathing."

It will be of interest to give Sir F. Hewitt's conclusions on ethyl chloride: " This is a useful anæsthetic for certain cases. It is a fairly good substitute for nitrous

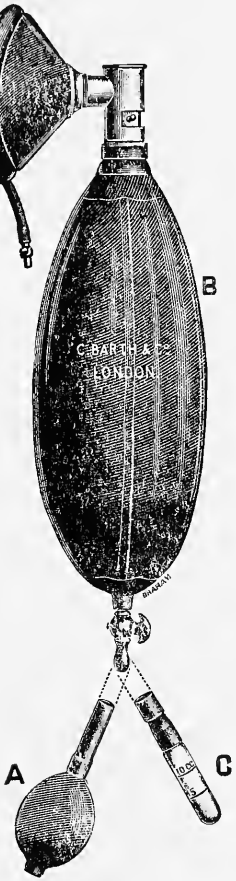

Fig. 29.—Hewitt's Ethyl Chloride Inhaler.

oxide when this gas cannot be obtained. It is, however, somewhat uncertain in its action, sometimes answering every possible requirement and fully satisfying the patient and his medical attendants, at other

times almost failing to produce anæsthesia. Its chief drawback lies in the frequency with which it produces unpleasant after-effects—headache, nausea, vomiting, and an indescribable feeling of depression. There is something almost characteristic in the distress which is liable to follow a full dose of ethyl chloride. There is less phonation under ethyl chloride than under pure nitrous oxide. Micturition seems a trifle more common under ethyl chloride. In addition to the after-effects mentioned, a feeling of heat is not uncommon. As a routine anæsthetic for short dental operations, ethyl chloride is distinctly inferior to nitrous oxide and oxygen, although it produces a longer anæsthesia. At the same time, its portability and simplicity of administration constitute important advantages, especially in crowded out-patient departments and in country practice. In small children who are about to undergo some brief dental or throat operation, and in those adults who are bad subjects for nitrous oxide or nitrous oxide and oxygen, ethyl chloride will generally answer well."

CHAPTER XIV

SPINAL ANALGESIA

Mr. Arthur E. Barker, F.R.C.S., has written several articles[1] describing the method of producing analgesia for operations up to the level of the diaphragm, which he has used extensively since 1907. Bier in 1898 and Tuffier subsequently had attempted spinal analgesia with cocaine, but with unsatisfactory results. Mr. Barker employs a solution of stovaine 5 per cent., glucose 5 per cent., and distilled water 90 per cent. by weight. Its specific gravity is 1023 at 15° C. He was the first to point out that this solution, owing to its greater weight (liquor spinalis having a specific gravity of 1·0070), could be made to travel up to any required level within the dural sac by slightly elevating the pelvis after its injection.

The operations first undertaken included those for strangulated hernia and radical cure for the inguinal, ventral, and femoral varieties of hernia, appendicectomy, colotomy, fissure and fistula in ano, varicose veins in the legs, and amputation of the thigh. He stated that the conditions produced from the operator's point of view were good. In from five to ten minutes, during which the final preparation of the field of operation,

[1] "A Report on Clinical Experiences with Spinal Analgesia in 100 Cases," *British Medical Journal*, March 23, 1907. *Ibid.*, February 1, 1908; August 22, 1908; and March 16, 1912.

of the hands, etc., was made, the patient, without any struggling, excitement, or coughing, was not only rendered analgesic, but also relaxed in all the parts supplied from below the segment reached. The main points of the technique are as follows:

The human spinal cord terminates at the lowest opposite the second lumbar vertebra, and is below this out of reach of harm. The fourth lumbar spine is recognized by being on a line uniting the highest points of the two iliac crests across the back. The hollow needle is thrust in just above this or the third spine and aimed straight forwards, and a little upwards. The patient during the puncture should sit on the edge of the table with the back rounded to its maximum. A second slender cannula is used to fit the first hollow needle loosely and project beyond its point about 1 mm. This cannula is attached to the syringe which is filled with the drug compound through it. When the puncture with the first hollow needle is made, the spinal fluid is allowed to run out through it to the amount of 10 c.cm., then the cannula attached to the charged syringe is passed through the first needle until its cone closes it. The syringe used has been that known as "The Record," holding 2 c.cm. In filling it, after sterilization, the end of one of Billon's ampoules containing the sterilized solution is broken off, the cannula attached to the syringe introduced into the fluid, and the piston withdrawn; 1 c.cm. of the solution is slowly delivered into the dural sac, the needle, cannula, and syringe are then withdrawn, and the puncture covered with collodion or rubber plaster at once. To secure perfect asepsis in the whole procedure is beyond everything absolutely necessary. All the

apparatus must be sterilized by boiling and set apart for spinal analgesia, and used for no other purpose. Neither soda nor other alkali must be used in the sterilizer, as these destroy the stovaine. The patient is now gently to be turned upon his back with the head and shoulders raised. The duration of analgesia is usually from one hour to an hour and a half. The patient is prevented from seeing the operation by means of a sloping screen which fits over the operating-table; ten minutes after the injection, faintness and sickness sometimes occur, probably on account of the loss of contractile power in the abdominal muscles. Raising the feet and legs will tend to relieve it, and injections of caffeine or strychnine may be called for. The blood-pressure may become lowered owing to the overfilling of the abdominal veins by loss of intra-abdominal pressure.

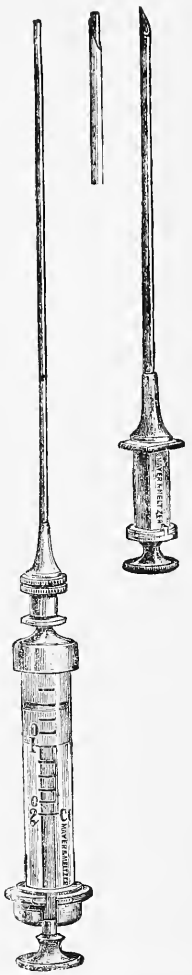

Fig. 30—Barker's Lumbar Puncture Syringe.

A low rate of mortality from this method can only be expected from the greatest care and skill in technique. It cannot be recommended for routine use, and nervous, excitable, and morbidly introspective patients should not be subjected to it. Other contra-indications are spinal diseases, local septic conditions over the

lumbar spine, operations above the umbilicus, or those requiring the Trendelenburg position[1]. On the other hand, it might be suitable in certain cases of acute lung diseases, pericarditis, cystitis with pyelitis, morbus cordis in the stage of broken compensation, diabetes with acetonæmia and threatening coma, and renal disease with incipient uræmia.

[1] Sir F. Hewitt, "Anæsthetics and their Administration," 5th edition, p. 522 *et seq.*

CHAPTER XV

ADENOIDS

The consideration of these cases must be prefaced in the reader's mind by the predominant fact that the patient's upper air-passages are more or less obstructed to the ingress and egress of air. The presence of obstruction to free respiration, varying in degree, but active to some extent in almost all cases of adenoid growths in the postnasal space, presents us with a subject for anæsthesia who differs from the normal healthy individual in a most important particular.

In view of the very high death-rate which at one time prevailed under the influence of chloroform for the removal of adenoid growths, a theory was advanced, and, indeed, obtained some footing, that a lymphatic diathesis existed in these patients, which was described as rendering them more prone to circulatory depression under chloroform than those in whom such glandular hypertrophies did not exist. Without expressing a definite opinion upon this question, as the subject is still *sub judice*, we may wisely regard the whole type of adenoid patient, with his slower intellect, deafness, congested upper air-passages, oral breathing, muco-purulent secretions, and arrested chest development, as one which is likely to exhibit unusual phenomena.

Two salient features, however, present themselves

in the asphyxial factors which are introduced in anæsthesia, and even during normal sleep, in the adenoid patient, (1) by the presence of the growth itself, and (2), at an operation, by blood and mucus, added to the intermittent interference with free respiration by the inevitable manipulations of the operator while working in the tidal airway.

These general considerations, however, should in no way reduce the importance of estimating the individual character and physical type of each patient.

The age of the subject should, of course, make a great difference, not only in the manner in which the anæsthetist should set about his task—children under four or five years being simply told that they are going to breathe a little "sweet air" or "scent," whilst older ones may be instructed to close their eyes, because they are going to be "put to sleep for a few minutes"—but in selecting the anæsthetic itself; the possibility of a long anæsthesia under nitrous oxide and oxygen, for instance, increasing exactly in proportion to the age, size, and development, of the patient to be operated upon.

As regards sex, it will generally be found that girls are far more tractable and easily managed than boys, for they appear to give their confidence more completely to their medical attendants, whilst boys seem to entertain a suspicion of being in some way deceived or taken by surprise in an unguarded moment. These therefore require a more frank and candid treatment, and, if over six or seven years of age, it is best to tell them that you are going to speak to them "just as if they were grown-up men," after which it will usually

be found that they will listen carefully to instructions and obey them to the letter.

The quantity of anæsthetic required is nearly always greater in males than females to produce a given result; but extra allowance must be made for females of masculine type and build, and *vice versa*.

Regarding the pathological state apart from the immediate symptoms due to nasal obstruction, the liability to bronchial catarrh in the subject of adenoid growths must be borne in mind, besides the excessive secretion of mucus in the mouth which is apt to occur under any irritating anæsthetic.

The chest, when free from other signs of disease, is often found to be deficient in the power of adequate expansion, and frequently also rickets may complicate the arrested thoracic development alluded to.

Other things being equal, a florid and well-nourished child is likely to take more anæsthetic, secrete more mucus, and to bleed more freely, than one of paler countenance and slighter build.

The best time of day for operating upon adenoids is that at which the patient's vitality is approaching the maximum, and at which, in small children, the needful abstinence from solid food will be least noticed and regretted. The hours between 9 a.m. and 11.30 a.m. seem to fulfil these conditions best, because no breakfast is required before the earlier time, if that be fixed upon, and only a cup of clear soup is needed at 8 a.m. if the operation be timed about noon. The last meal the night before should consist of soft bread and milk, or biscuits soaked in milk, at 6 or 7 p.m., or whatever meal the child is accustomed to before bedtime, with as little departure as possible from

regular habits. Apprehension of an operation will often completely arrest digestion, and six or seven hours after a semi-solid meal undigested food may be vomited during an operation late in the day. When starved for several hours, children are apt to purloin apples or nuts to satisfy their hunger, and it is better to give them soup and toast at noon than to run the risk of vomiting occurring at an operation in the afternoon. The writer once administered gas and ether to a boy of twelve who was said to have just had his tea. The operation being very urgent, the meal was regarded as unlikely to interfere seriously with the anæsthesia. During recovery, however, the child's upper air-passages became entirely blocked with semi-fluid masses of undigested food, and it was with the greatest difficulty that he was kept breathing, without recourse to tracheotomy, till the vomiting was over. It was then admitted that he had had six large slices of bread and butter at his recent meal.

It is always distinctly of advantage for the parents of the patient not to be present at all during the induction of anæsthesia or the operation, for the child and parent constitute a far more unmanageable combination than any patient with a proper nurse who knows her business.

The question of posture is largely dependent upon the nature of the operation to be performed. If the surgeon desires merely to thoroughly scrape the naso-pharynx, a proceeding only occupying a minute or so of time, the administration of nitrous oxide and oxygen in the sitting position is a perfectly safe and adequate method; it can, however, hardly be advocated in very small children, on account of the very

FIG. 1.—DORSAL POSTURE DURING REMOVAL OF TONSILS AND ADENOIDS.

Head lowered and slightly extended. Mouth opened by gag. Anæsthetist supporting chin to keep gag in place and airway free.

FIG. 2.—LATERO-PRONE POSTURE FOR RECOVERY.

Patient's face towards floor. Mouth open. Upper leg drawn forward and knee bent to prevent rolling of the body backwards.

To face page 172.

short duration of the unconsciousness it produces. For the more extensive operations, involving the use of a curette and Löwenberg's forceps, the dorsal position is to be recommended, with the head occasionally turned to the side for drainage of blood and débris. For several years the dorsal posture, with the head completely dependent over the end of the table, has been in vogue, with the view of avoiding the danger of foreign matters entering the lower air-passages. It has been found, however, that such extension of the neck produces painful stiffness, and that the prominence of the bodies of the vertebræ within the pharynx renders the scraping of its surface more difficult of performance; the blood also, which was supposed to drain out through the nose, is very apt to coagulate and block that passage early in the operation. Reliance is better placed upon maintaining a lighter form of anæsthesia, in which the coughing and swallowing reflexes are retained, and foreign matters thereby removed from the superior aperture of the larynx. It is well to request the assistance of a third person during the operation, to aid in turning the patient on to his side from time to time; but if the surgeon is content to operate with his subject in the lateral posture, no such help is required, for drainage will be complete from the lower side of the mouth.

During the operation and for an hour afterwards great care should be taken that large surfaces of the patient be not exposed to the air, for lowered temperature is a fruitful source of depression when added to loss of blood and impending vomiting.

There is no doubt whatever in the writer's mind that a mixture of two parts of chloroform and three

parts of ether by volume constitutes an ideal inhalation for the extirpation of adenoids. This mixture is best administered on a Skinner's mask, for the colour of the patient's face, his breathing, and general circulation, will be found to be deeper and more satisfactory than under chloroform alone, and less hampered by the presence of mucus and free bleeding than under the influence of pure ether. When the surgical procedure is likely to be prolonged, a Junker's apparatus filled with C_2E_3 mixture may be employed to maintain the narcosis for any required period of time. The usual duration of available anæsthesia after the inhalation of the C_2E_3 mixture to that degree where corneal reflex is decidedly sluggish will be about four or five minutes, and this suffices for all but the most methodical procedures.

The exact manner in which to induce anæsthesia will now be described. Three ounces of the mixture should be prepared. The patient's head is gently turned to the right side. The mask is now gradually brought to within an inch of the patient's mouth, and he is instructed to blow into it quietly and slowly. The anæsthetist, resting his left arm and wrist on the left side of the patient's head, now grasps the mask with his left hand, and pours small quantities of the mixture from his Thomas's drop-bottle upon the lower quadrant of the mask opposite to the patient's mouth.

The whole art of inducing anæsthesia is that of verbally encouraging the patient to breathe regularly until unconsciousness is attained, and advantage should be taken of regular breathing to increase the strength of vapour fairly rapidly from the beginning. This method avoids any possibility of vomiting, and

produces the requisite degree of anæsthesia within five minutes. The mixture should be used quite freely, and $1\frac{1}{2}$ ounces of the liquid may be necessary to anæsthetize a boy of twelve years of age. His colour during this time should be a bright pink, his breathing audible and regular, without struggling or any inconvenient movement whatever. When the pupil is of moderate size, the limbs flaccid, and the corneal reflex dulled in activity, the mask is to be removed. A Mason's gag is inserted between the patient's teeth on the left side of the mouth, and opened fairly wide for the surgeon to begin. Some operators may require the head to be in the mid-line, with the face to the ceiling; and if this is done, several sponges, about the size of a small orange, should be at hand for cleansing the back of the throat. The anæsthetist may be required to do this, but should not relinquish the gag, nor allow his attention to be diverted from the respiration, which must never become obstructed, or even slightly hampered, for more than two breaths at a time throughout the operation. This is very necessary in weakly subjects, because secondary cardiac depression is likely to follow upon a congested state of the venous system. In case of accidents apart from hæmorrhage, which is the surgeon's special care, lowering of the head, drawing forward the tongue, clearing the airway, and regular compression of the chest (*i.e.*, efficient artificial respiration), will certainly restore patients suffering from temporary circulatory failure or respiratory obstruction. Many drugs have been advocated in such emergencies, but a few whiffs of ether form a more rapidly absorbed stimulant than any hypodermic injection when the vitality is depressed.

There can be little doubt that the administration of an anæsthetic in these cases is fraught with real danger to life in inexperienced hands, for the asphyxial elements indicated above are exceedingly subtle in their appearance, and cannot be successfully eliminated unless their onset is perfectly clearly recognized in a very early stage. The fact is incontrovertible that chloroform alone is incapable of producing dangerous symptoms if the administrator be thoroughly versed in the clinical evidences of the various degrees of narcosis; but when depressing influences are added to the lower blood-pressure which it produces, a very slight change in posture, an attempt at retching, slight obstruction to breathing, or exposure to cold air, with much hæmorrhage, will extinguish the vitality which could otherwise be preserved.

Numerous instances are recorded also where the patient has succumbed before the operation has commenced. This may occur in two ways—by simple over-dosage or by timid administration. The latter involves all the dangers and difficulties of a prolonged second stage. When a patient is allowed to vomit frequently while being anæsthetized, sufficient anæsthetic is not being given; and if this second stage be prolonged, as in many of the cases of reported fatalities, syncope may be induced from this cause alone. Unrecognized obstruction to breathing is, however, the chief cause of deaths in most chloroform accidents. Movements of the chest alone are not sufficient evidence that adequate respiration is proceeding. Each fresh breath must be either heard or felt by the administrator, and the holding of the breath during struggling, the delayed deglutition movements and entry of blood

or high-pitched crowing indicating partial spasm of the larynx, must all be met by immediate treatment to clear the airway, because otherwise secondary syncope soon follows in their train.

A classical paper by Hinkel[1] records eighteen cases of death under chloroform administered for the removal of postnasal growths, at the end of which he concludes that—

1. Statistics show an exceptionally high mortality from chloroform anæsthesia in the operation for the removal of lymphoid hypertrophies of the pharynx.
2. The observations of the Vienna pathologists show that sufferers from "adenoids" frequently belong to an abnormal constitutional type that has been found peculiarly susceptible to chloroform narcosis.
3. In view of the statistical and pathological data presented, the general use of chloroform in the operation for hypertrophied tonsils or naso-pharyngeal adenoids is inadmissible.

These opinions are very clearly expressed, and appear somewhat dogmatic in view of the general resort to chloroform in the English country districts. It is difficult, however, to refrain from holding the view that, if some such mixture with ether as that which has been described above were more usually adopted, those whose experience is only moderate would be administering a far less lethal vapour than that of chloroform in these particular operations.

Lymphatism or status lymphaticus is a disease in which chronic enlargement of the lymphatic glands, tonsils, and thymus gland co-exist, and has been found to produce sudden death under anæsthetics.[2]

[1] *New York Medical Journal*, October 29, 1898.

[2] Proceedings of the Royal Society of Medicine, section of Anæsthetics, December 3, 1909.

CHAPTER XVI

INTRANASAL OPERATIONS

The extreme difficulty of estimating the probable length of these operations, however trifling the surgical manœuvre may previously appear to be, should render the anæsthetist always careful to induce a suitable degree of anæsthesia, and to maintain the same by means of the mouth-tube from Junker's chloroform bottle before their commencement.

The nasal mucosa is exceedingly sensitive to surgical manipulation, and experience shows that the above is the only method in which the administrator's reputation is not momentarily jeopardized by reflex movement, rigidity, or retching, on the part of the patient, and that there is hardly any other operation in which exact knowledge of the particular surgeon and his methods during the various stages of the procedure are more necessary to the administrator, both to insure the efficiency of the anæsthesia and freedom from accidents.

Venous engorgement of the patient's system, and congestion of the nasal mucosa, are so disastrous to efficient intranasal surgery that the indication is to prevent these by every means available.

Fifteen or twenty minutes before the induction of anæsthesia the surgeon usually inserts a pledget of wool, soaked in a solution of equal parts of 10 to

15 per cent. cocaine and 1 in 1,000 adrenalin solution, into one or both of the nasal cavities, with the object of producing a local ischæmia and partial anæsthesia of the mucous membranes—results which are of considerable advantage to the administrator in reducing the amount of blood effused into the air-passages, and rendering very profound narcosis unnecessary.

The anæsthetic used should irritate the air-passage as little as possible, and it is for this reason that pure chloroform, or the C_2E_3 mixture followed by chloroform, from the tube of Junker's apparatus, introduced into the mouth, is most suitable for these cases. If

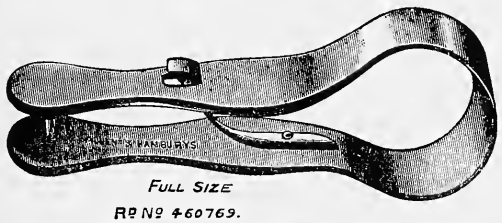

Fig. 31.—Author's Tongue Clip.

the patient be seated upright, in order to avoid a fall of blood-pressure, it will be wise to commence anæsthesia in the early stages with the C_2E_3 mixture, but after the third degree of narcosis has been attained it is permissible to continue with chloroform, and afterwards maintain a light form of this degree for the operation.

Owing to the possibility of blood and débris entering the larynx and trachea, the conduct of the anæsthetic administration during intranasal operations must be thought out and planned beforehand with the surgeon with the utmost care.

In the first place, in order to facilitate the opera-

tion by the avoidance of expiratory blood-spraying over the operator and inspiratory blood-aspiration into the naso-pharynx, complete mouth-breathing should be established and maintained throughout the anæsthesia.

This can be done by the preliminary insertion of a mouth-prop between the teeth or gums, or a Mason's mouth-gag, directly automatic breathing arises. At this latter moment a silk ligature for the anæsthetist to hold should be passed through the tongue $\frac{1}{3}$ inch

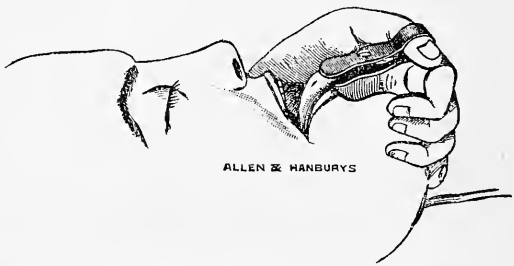

Fig. 32.—Author's Tongue Clip in Position.

The sterilized clip is to be passed over the tip of the tongue during anæsthesia, and clamped upon it $\frac{1}{2}$ inch from the edge in the mid-line. The tongue can then be gently held forward by the anæsthetist's forefinger or thumb. This will be found especially useful during operations upon the upper air-passages.

from the tip in the mid-line, or, better still, the tongue clip (see Figs. 31 and 32) may be inserted in the same spot, with either of which that organ may be drawn gently forward away from the pharynx and kept there.

Further, if the nature of the operation permit, a sterilized honeycomb sponge the size of a tangerine orange, tied to the middle of a 2-foot length of tape, should be now passed through the mouth and tucked up behind the uvula and soft palate into the naso-pharynx, one free end of the tape being drawn out

through a nostril by means of polypus forceps, and the other end left hanging from the mouth (captive sponge).

In doing this, care must be taken that the uvula and soft palate are not bruised or folded backwards by the sponge.

It is evident that all further difficulty to the anæsthetist from the possible invasion of the larynx by fluid and débris will be thus avoided, and a moderate surgical degree of narcosis may be safely maintained.

If the nature of the intranasal operation does not permit the presence of a captive sponge in the naso-pharynx—*e.g.*, operations upon the sphenoidal sinuses

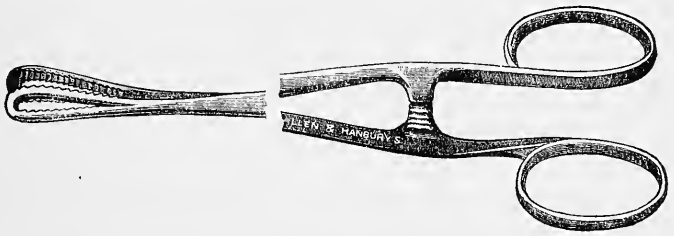

Fig. 33.—Rampley's Improved Sponge-holding Forceps.

and posterior ends of the inferior turbinate bones—a number of damp sterilized honeycomb sponges must be placed at hand in a bowl, for the administrator to pick up with long-handled sponge forceps, in order to sponge out the pharynx from time to time as it becomes filled with blood (Fig. 33).

The sponge-holders usually sold for this purpose should not be used, because their hold upon the sponge is often lost by contact of the distal catch with the gag or patient's teeth, with the result that the loose sponge may fall into the throat and cause unnecessary delay, if not dangerous asphyxial symptoms, before it is secured.

In these operations without a captive postnasal sponge, a lighter degree of narcosis must be preserved —namely, the early stages only of the third degree, in which the laryngeal reflexes are sufficiently active to allow the patient to give an occasional cough to clear the airway.

When the patient is seated quite upright in a chair,

FIG. 34.—LONGHURST'S TONGUE DEPRESSOR.

Longhurst's tongue depressor can be conveniently made to keep the base of the tongue from falling back in patients with a large loose tongue or enlarged tonsils, which tend to obstruct the airway. It is fitted with a tube for the attachment of the Junker apparatus.

the need for either a postnasal captive sponge or such frequent throat-sponging is not so marked, for by tilting the head forwards drainage of blood can be directed towards the anterior nares when required; but only the early stages of the third degree of narcosis are permissible, in order that the laryngeal reflexes may be preserved, as in the cases last described.

CHAPTER XVII

ABDOMINAL OPERATIONS

The main requirements of the surgeon during these operations are—(1) quiet respiration and (2) flaccidity of the abdominal wall.

Quiet respiration can usually be obtained by keeping the airway perfectly clear, and the use of chloroform or its mixtures instead of ether after the induction stages.

Flaccidity of the abdominal wall in some instances is exceedingly difficult to produce.

When we desire to examine the abdominal organs of a patient who is lying on his back awake, in order to obtain relaxation of the recti muscles, we instruct him to breathe through the mouth and draw up the knees, thereby flexing the spine and bringing the pelvic insertions of the recti nearer to the xiphoid cartilage and ribs; but in anæsthesia this is very rarely thought of, the surgeon merely complaining of rigidity in the abdominal wall, and expecting the anæsthetic to relax it.

In thin subjects especially, when relaxation appears otherwise difficult to obtain during anæsthesia, the approximation of the origins and insertions of the recti will often render it quite easy; the knees need only be raised to a slight extent on a pillow, but the head and shoulders as well must be raised and flexed

a little with the same object, because extension of the head upon the spine, and of the spine itself also, definitely tighten the abdominal wall.

Abdominal rigidity may be due to tonic muscular contraction—

1. As a part of general rigidity in the second stage of anæsthesia.
2. As a result of general anoxæmia.
3. Of a protective character in peritonitis and over inflamed or painful areas.

Or may arise from excessive active contractions—

4. During the act of retching.
5. As an habitual expiratory effort in certain pulmonary diseases.
6. As a reflex from surgical manipulation.

Whether tonic or intermittently active, the rigidity due to *Causes* 1, 3, 4, and 6, can as a rule be abolished by inducing a deeper stage of narcosis, though powerful, alcoholic, and highly nervous subjects may require considerable quantities of anæsthetic to attain it.

The ease with which relaxation can be produced also depends upon the site of operation. Incisions above the level of the umbilicus often cause reflex laryngeal spasm and muscular rigidity, which are not so apt to arise during operations below this level.

The abdominal wall over an inflamed organ or the seat of an abscess is often in a state of tonic contraction, and a certain board-like hardness of the abdominal superfices is also found in toxic conditions, including peritonitis. These forms of rigidity relax in the surgical degree of anæsthesia.

Cause 2 requires the admission of more air by mechanical means if the air-passages be obstructed, such as

opening the mouth, drawing the tongue forward, and withholding the anæsthetic for a time, or changing to a more "open" method of administration.

Anoxæmia caused by reflex laryngeal spasm requires brisk lip-rubbing as well as these measures, and possibly also the temporary cessation of surgical manipulations till a more satisfactory freedom of airway and colour are regained and the anæsthesia has been deepened.

Cause 5.—There is a particular class of patient in relaxing whom there is likely to be considerable difficulty. These are the subjects of asthma, chronic bronchitis, and emphysema, whose abdominal muscles have by long use become habitual muscles of expiration, aiding this function in the absence of thoracic resilience by contracting upon the abdominal contents and forcing them upward upon the diaphragm and bases of the lungs.

It will be seen that, thoracic expiration in these patients having been replaced by habitual abdominal expiration, in anæsthesia the abolition of all power of abdominal contraction is very likely to bring respiration to a standstill, and, at any rate, will result in some cyanosis due to lack of elimination of carbonic acid gas. Instead, therefore, of expecting complete relaxation in such patients, the incision should be enlarged and the muscles held aside with large retractors, while breathing of a moderately deep character is allowed to proceed.

CHAPTER XVIII

RECTAL OPERATIONS

Certain special factors which must be clearly grasped and prepared for by the administrator are liable to complicate the smoothness of anæsthesia during operations upon the rectum.

Before the surgeon can view the area of disease, the external sphincter ani must be stretched until completely relaxed. Now, hardly any other region of the body is more sensitive or produces more violent reflex effects during manipulation than this sphincter; and as the stretching is required at the beginning of the operation, when anæsthesia has not long been established, inconvenient rigidity, and even movement of the patient's legs, are apt to result unless the deep stage of the third degree of narcosis has been thoroughly attained. In addition to these muscular phenomena, violent and prolonged deep inspirations accompanied by acute laryngeal spasm, evidenced by loud high-pitched "crowing" breathing, almost invariably take place at the same moment.

The indications, therefore, are to render anæsthesia profound before sphincter-stretching begins, in order to abrogate as much as possible the transmission of nervous stimuli, and to divert the effect upon the respiration and larynx, if it can be done.

The effect of deep ether narcosis at this point, as compared with chloroform, is far more advantageous

in both directions, the "pushing" of ether being less dangerous than that of the other anæsthetics; whilst the very ample depth of breathing it produces keeps the respiratory mechanism working harder against the inspiratory obstruction of laryngeal spasm, which under chloroform may become complete.

It is well, therefore, to insert a small mouth-prop before the commencement of the operation in all rectal operations, to facilitate the entrance of air when the difficulty in respiration arises.

A considerable stimulation of respiration can be produced by briskly rubbing the patient's lips with a dry and preferably rather rough towel—so much so, in many cases, that this stimulus alone is capable of diverting or neutralizing the reflex effect of sphincter-stretching upon the larynx, and relaxing an obstructive spasm which threatens to produce anoxæmic and asphyxial symptoms.

If the operation be performed with the patient in the lateral posture, no real difficulties need be anticipated; but when the lithotomy position is needed, the additional tendency for mucus to run backwards in the mouth towards the larynx, and for the tongue to gravitate against the pharyngeal wall, render it advisable to turn the patient's head well to the side in order to maintain the patency of the airway.

If the laryngeal spasm result in respiratory cessation at the end of a deep inspiration, the surgeon should first be asked to desist for a short while—as breathing will certainly not in that case recommence while the sphincter-stretching goes on—the lips should be briskly rubbed with a rough towel, and, if this has no effect, the tongue should be drawn forward and a few pressures

should be made upon the sternum, when there is no doubt that the spasm will relax and respiratory obstruction be overcome. It cannot be said that after the sphincter has been relaxed all danger of reflex effects upon the larynx is at an end, for in the author's experience dragging upon the rectal mucosa, and also the application of the cautery or very hot water within the rectum, are also liable to produce the same effect.

During the removal of hæmorrhoids and excision of the rectum, large quantities of blood are sometimes lost rapidly, and the immediate effect upon respiration is to render it shallow and inaudible, at the same time producing an apparent deepening of anæsthesia, which is probably dependent upon a transient lowering of blood-pressure and lessened elimination of anæsthetic vapour from the lungs. At such junctures the lips and face should be well rubbed, and the jaw pushed forward from the angle, whilst the anæsthetic is withheld until distinct signs of recovery are apparent. When such symptoms have occurred, only a very small amount of anæsthetic is afterwards required to keep the patient tranquil.

Kraske's operation for removal of the rectum, including a portion of the sacrum and coccyx, is in many instances a formidable one in which to undertake the conduct of the anæsthetic. This is not so much on account of laryngeal spasm, which does not so readily arise in this area of operation, but because of the cachectic or senile condition of the patients for whom it is mostly undertaken, and the considerable loss of blood and exposure involved by this lengthy operation.

The posture adopted, which is now generally the semiprone, though it should be preferably the left lateral one,

is unfavourable to efficient expansion of the chest wall. Ether in the early stages, followed by the C_2E_3 mixture or chloroform in small quantity, is best adapted to these patients. An occasional return may be made to ether if it be necessary to stimulate a flagging circulation. The application of many warm blankets for the prevention of undue exposure of the patient's body, and the infusion of saline solution into the cellular tissues of the axillary spaces when surgical shock becomes apparent, will best aid in steering such a case in safety back to bed.

CHAPTER XIX

OPERATIONS UPON THE BLADDER

The special difficulty which is encountered during lithotrity and other manœuvres requiring the distension of the bladder with fluid is chiefly a tendency to straining during expiration, and to rigidity of the abdominal recti; though the inspiratory laryngeal spasm met with in rectal operations may also arise and increase the disturbance of tranquillity and adequate respiratory interchange.

The most common type of subject for lithotrity is the somewhat obese and elderly male patient, of full-blooded if not alcoholic habit, whose lungs are often emphysematous and arteries definitely degenerate.

No anæsthetic but chloroform should or can be properly employed for these people, and unless special circumstances, such as a badly diseased heart or extreme fear of the anæsthetic, point to the use of the C_2E_3 mixture, any other anæsthetic will rarely be of service in overcoming the difficulties enumerated, which must be met by other means.

The fluid used by the surgeon for distending the bladder should be neither too hot nor too cold, but as nearly as possible at the body temperature; for a mistake in either direction frequently tends to "crowing," straining, and rigidity, with secondary cyanosis of the face, lips, and ears.

The raising of the pelvis upon a pillow often leads to respiratory trouble in stout old men by throwing the weight of the abdominal contents against the diaphragm and hampering its descent. The abdominal recti may also be tightly stretched between their attachments by this procedure, and cause a rigidity which chloroform cannot relax. If the above-mentioned mistakes have been avoided, reflex crowing and straining may often be minimized, and even abolished, by briskly rubbing the patient's lips with a rough dry towel; but if this be of no avail, the insertion of a gag or small mouth-prop, and the pushing of the lower jaw well forward, with slight extension of the head backwards, will usually be efficacious. The tongue may also be drawn forward with the tongue clip. If, however, real anoxæmic symptoms arise from the reflex respiratory disturbance, the bladder distension must be relaxed until these have been relieved. We may here draw attention to a pitfall in the signs of anæsthesia which the inexperienced administrator meets in these cases and in other operations involving considerable reflex stimulation of breathing by the surgical manipulations.

The respiration, instead of becoming strained or crowing in character, in some cases merely grows deeper and quicker during the introduction of instruments and distension of the bladder. If the corneal lid reflex be kept very weak in action during these moments of surgical interference, directly these stimulations cease the anæsthetist will discover that the lid reflex has quite disappeared, and that the breathing has died down to a very shallow movement. As a matter of fact, the patient has been overdosed with the anæsthetic.

The explanation is a very simple one—namely, that

it was the *surgical stimulation* that kept the breathing going freely and the corneal lid reflex partly active; for it often happens that a patient may be brought round to exhibit deep breathing and active reflexes by manipulations of sensitive parts, and will fall back into a very profound narcosis when they cease, if he has been dosed up to entire tranquillity while they continue.

The practical way of avoiding this trouble is to lighten the anæsthesia towards the end of each strong stimulation, asking the surgeon to afford full warning of the withdrawal of fluid from the bladder, or anticipating the same by personal observation of his actions.

CHAPTER XX

VAGINAL OPERATIONS

The management of these cases much resembles that of patients undergoing rectal operations. The sex and age of the majority of cases requiring vaginal operations (between twenty and forty-five years) render them comparatively easy to anæsthetize, and, unless the individual be extremely fat or bronchitic, ether is usually taken extremely well.

The dilatation of the cervix uteri is usually the only part of the operation likely to cause respiratory "crowing," but in deep ether anæsthesia this is rarely sufficiently obstructive to cause anoxæmia, owing to the amplitude of respiratory movement under this anæsthetic.

When Clover's crutch is used to truss the patient in the lithotomy position, care must be taken that the circulation in the legs is not hampered by the pressure of the circlets and leather straps, and that the thighs are not flexed upon the abdomen so far as to hamper respiration.

The choice of anæsthetic in elderly or otherwise diseased patients must depend upon the general principles elsewhere laid down. Vaginal hysterectomy, which is the most formidable of the vaginal operations, and occasionally curetting of the uterine cavity, involve considerable and rapid loss of blood, for which

the anæsthetist must be on his guard, ready to lessen the depth of narcosis in case the respiration become shallow from lowered blood-pressure and anæmia of the cerebral centres.

During plastic operations on these parts, a change to the C_2E_3 mixture or chloroform will often secure freedom from the free hæmorrhage or oozing of the cut surfaces by which the surgeon may be delayed when ether is being administered.

CHAPTER XXI

SURGICAL SHOCK

Shock, by which term is meant the depressing effect due to the operation itself, is not entirely prevented by anæsthesia. It is caused by afferent stimuli transmitted from the operation area, during the stretching, tearing, or section, of nerves and nerve-endings, to the respiratory, vasomotor, and cardiac centres of the brain, which become gradually exhausted by over-stimulation.

The effect of shock upon the respiratory centre produces deep crowing inspiration and laryngeal spasm.

The effect upon the vasomotor centre produces a fall in the general blood-pressure, and the effect upon the cardiac centre produces rapid and irregular action of the heart.

Shock is precipitated and intensified by hæmorrhage and by the exposure of internal organs and large superficial areas to cold.

Shock is evidenced by pallor of the face and skin surface of the body, accompanied by feeble respiration, separation of the eyelids, loss of tension in the ocular globes, cold sweating, especially of the forehead, and a rapid, small pulse, tending to become irregular in force and rhythm.

Certain procedures and circumstances inseparable from abdominal operations are liable to cause shock—

namely: (1) Reduction of intra-abdominal pressure by the opening of the abdomen and the removal of fluid and tumours which have caused pressure upon the splanchnic area; (2) dragging upon the peritoneum, especially ot Douglas's pouch, and upon the pedicles of abdominal organs or on the spermatic cord; and (3) handling and exposure of the stomach and intestines.

Other manipulations producing marked shock are the removal of the whole breast from the pectoral muscle, and the jarring of the skull by the use of a mallet and chisel during the mastoid operation.

The indications for the prevention of shock ara— (1) To avoid rough handling of sensitive areas, and to let fluids flow out slowly, in order to give time for the readjustment of blood-pressure. (2) To prevent the passage of nerve stimuli by blunting the sensibility of the nerve trunks and terminals as far as possible. Ether is decidedly a better obtundent than chloroform. The hypodermic injection of $\frac{1}{6}$ grain of hydrochlorate of morphine combined with $\frac{1}{120}$ grain of sulphate of atropine, fifteen minutes before the administration of the anæsthetic, is also an excellent adjuvant in this respect. (3) To maintain the blood-pressure at the normal level.

Large surfaces of the body near the wound should not be exposed or covered with wet cloths, which produce rapid chilling of the skin by cooling and evaporation; and if these are to be used, mackintosh, and if possible blanket also, should lie beneath them.

It must not be forgotten in this connection that exposed intestines and other vascular organs produce a rapid loss of heat, and should be covered, when drawn

out, by a succession of warm sponges or wads of gauze. A patient always begins to flag when eviscerated bowel is allowed to cool.

The administration of small doses of tincture of nux vomica three times daily for a week before the operation improves the vascular tone, and tends to prevent a marked fall of blood-pressure during its performance.

The use of ether as the anæsthetic avoids the characteristic fall of blood-pressure which occurs under chloroform.

In the deeper stages of the third or surgical degree of anæsthesia there is a tendency for the vaso-constrictor mechanism to become paralyzed, and if the patient's head be raised, the cerebral centres become anæmic from the gravitation of the blood towards the splanchnic area. By keeping the head low and the lower limbs raised, these centres are fed with blood, and the pressure does not fall. The Trendelenburg posture is therefore valuable in preventing a fall of blood-pressure.

After an operation conducted in either the Trendelenburg or the lithotomy position, if hæmorrhage has occurred, it is best not to let the patient down flat at its termination, but to keep the feet raised for some hours afterwards, to prevent the supervention of cerebral anæmia before the blood-pressure has returned to normal level.

Whenever shock or hæmorrhage begins to appear, the anæsthesia should be lightened, so that the vasomotor system may recover its activity and readjust the disturbed blood-pressure.

Besides shock, lowering of general blood-pressure, with feeble respiration due to anæmia of the medullary centres, may occur from hæmorrhage alone. The

anæsthetist should inform the surgeon that the loss of blood is affecting the patient when he *first* observes a change in the depth of respiration, other causes in his judgment being excluded, *before* blanching of the skin has definitely appeared.

Recovery of vascular tone and respiration is remarkably rapid from the moment of complete arrest of hæmorrhage, and this is the most urgent and vitally

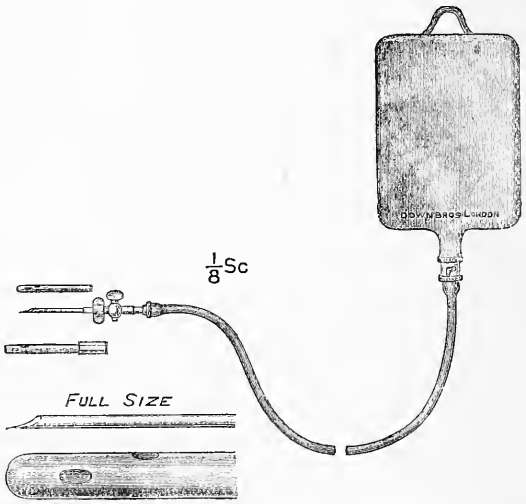

Fig. 35.—Arbuthnot Lane's Saline Infusion Apparatus.

important treatment. The injection of $1\frac{1}{2}$ pints or more of hot saline solution into the rectum, with raising of the feet and lowering of the head, are next in value. A funnel, tubing, and silver nozzle for the transfusion of saline fluid into a vein of the arm, should always be at hand in case of more severe hæmorrhage.

Eight ounces of saline infusion may also be allowed to run into the cellular tissues of either or both axillæ by inserting a hollow needle in a downward and back-

ward direction at the outer edge of the pectoralis major muscle.

This can be most conveniently done by the surgeon's assistant, by means of Sir Arbuthnot Lane's apparatus, shown in Fig. 35. Great care, however, must be taken that the water-pressure be not sufficient to blanch the skin by distension, or it may afterwards slough.

CHAPTER XXII

ANOCI-ASSOCIATION

Dr. G. W. Crile, of Cleveland, Ohio, published an article on "The Kinetic Theory of Shock" in *The Lancet*, July 5, 1913, in which he demonstrated the advantages of a new system by which all nocuous mental and traumatic factors might be eliminated from the environment of surgical operations. From this article the following passages may be quoted, giving a summary of his theory and technique:

This principle can best be expressed by coining a new word—viz., anoci-association. An adequate stimulus with or without inhalation anæsthesia, whether from trauma or from emotion, causes the brain cells to discharge some of their stored energy—that is to say, the sight of the operating-room, the spoken word implying danger, the taking of the anæsthetic, the instrumental injury of tissues in the course of the operation, and the traction of the stitches after operation, all are adequate stimuli. Therefore, the stored energy of the brain cells is consumed during surgical operations and during psychic strain. Obviously the only practical method of preventing the consumption of this stored energy of the brain cells is the development of a principle of operative surgery, the practice of which will exclude from the brain the stimuli of the special senses and the stimuli of common sensation. This is the principle of *anoci-association*, meaning the exclusion of all *nocuous* or harmful *associations* or stimuli.

The principle of anoci-association may be illustrated

by the wrecked *Titanic*. The story of the stress and the psychic strain of the survivors is known, that of the lost may easily be imagined; the future haunting memory of this experience by the survivors may be safely predicted. Such is the result of the conventional surgical operation. Now, if a survivor of this ship had been so skilfully anæsthetized on his bed just before the accident that he knew nothing of the impending disaster, and if he then had been gently carried up on deck, lowered into a lifeboat, and taken aboard the rescue ship without being allowed to awaken from his anæsthesia until in bed in a comfortable state-room —if then he was told that he had been transferred from the sinking ship, but that he was now safe and would soon see his home, this would be anoci-association.

Now, is there a single anæsthetic that would exclude all nocuous or harmful physical and psychic stimuli from the brain? By blocking nerve conduction local anæsthetics protect the brain from local operative injury, but they do not protect the brain against destructive psychic strain; inhalation anæsthetics exclude the psychic stimulation of the brain cells, but do *not* exclude the operative stimulation; and anæsthetics introduced hypodermically, being uncontrollable, are excluded on principle. Each anæsthetic covers a part of the field, but there is no single agent that *alone* can produce *anoci-association*, which is the goal of operative surgery. We therefore do not advocate ether alone, nor chloroform alone, nor nitrous oxide alone; we do not advocate local anæsthesia alone, nor morphine and scopolamine alone, nor spinal anæsthesia alone; but through *selection* and *combination* of anæsthetics we aim to attain an anæsthesia that will exclude all stimuli from the brain, and thereby attain anoci-association.

The description of this technique will be limited to abdominal and goitre operations, which will serve as illustrations of the principle.

Abdominal Operations

1st.—Excluding infancy, old age, and depressed vitality, we first administer, as an average, 1/6th of a grain of morphine and 1/150th of a grain of scopolamine one hour before operation.

2nd.—If local anæsthesia alone is employed, novocaine in 1/400 solution is used by progressive local infiltration.

3rd.—If inhalation anæsthesia is employed, we administer nitrous oxide—either alone or with ether added as required.

4th.—As soon as the patient is unconscious, first the skin and then the subcutaneous tissue is infiltrated with 1/400 novocaine. In order to spread the novocaine, immediate local pressure is applied with the hand. Anæsthesia is immediate. Incision through this anæsthetized zone exposes the fascia. The fascia is then novocainized, subjected to pressure, and divided. This brings us to the remaining muscle or posterior sheath and to the peritoneum. These structures are then infiltrated with novocaine, subjected to pressure, and divided within the blocked zone. If blocking has been complete, then upon opening the abdomen there will be found no increased intra-abdominal pressure, no tendency to expulsion of the intestines, and no muscular rigidity.

5th.—The peritoneum is next everted and a ½ per cent. solution of quinine and urea hydrochloride is infiltrated about the line of proposed sutures, and as before the parts are then subjected to momentary pressure. This infiltration serves as a block, and as its effects last for several days it should prevent, or at least minimize, the post-operative wound pain and the post-operative gas pains, and by so much minimize post-operative shock. Quinine and urea causes a certain amount of œdema of tissue, which lasts for some time after the wound is healed.

6th.—The relaxed abdominal wall will permit exploration of the entire abdominal cavity with ease. If there is no cancer nor acute infection in the field of operation, then the following regions may be blocked as completely and in the same manner as the abdominal wall—viz., the meso-appendix, the base of the gall-bladder, the uterus, the broad ligaments and the round ligaments, the mesentery, and any portion of the peritoneum. On account of the absence of nociceptors, operations on the stomach and intestines made without pulling on their attachment cause no pain, and hence the novocaine infiltration of these viscera is not required. If the brain has received no stimuli during the operation, then the closure of the upper abdomen is as easy as the closure of the lower—all is done with the ease of relaxation. What is the result ? No matter how extensive the operation, no matter how weak the patient, no matter what part is involved, if *anoci* technique is perfectly carried out, the pulse-rate at the end of the operation is the same as at the beginning. The post-operative rise of temperature, the acceleration of the pulse, the pain, the nausea, and the distension, are minimized or wholly prevented.

Graves's Disease

I believe everyone will agree that a technique that can carry an advanced exophthalmic goitre case through an operation without increasing the pulse-rate can all the more readily do as much for any other operation. This can be done by the following technique, the operation being either ligation or lobectomy. The patient's consent to an operation is secured before hospital treatment is begun.

Ligation is performed without removing the patient from bed. In performing ligation nitrous oxide and oxygen may or may not be administered; but the brain is always protected by a complete local blocking with novocaine during operation, and a complete quinine

and urea hydrochloride infiltration at the close of the operation.

If *lobectomy* is performed, the patient is anæsthetized with nitrous oxide-oxygen in bed. As fictitious anæsthesia has been given under the guise of treatment for several days previous to the operation, the patient when anæsthetized is free from psychic strain, as he is under the impression that he is receiving an inhalation treatment.

When anæsthetized the patient is taken to the operating-room. The division of tissue is preceded by a blocking so complete that no activating impulse can reach the brain. Before the wound is closed every part of the field is completely blocked by quinine and urea hydrochloride injected with a hypodermic needle. The patient is kept unconscious, under anæsthesia, until he has returned to his room and until his room is restored to its condition when administration of the anæsthetic was begun. Since in the course of the cycle from his room to operation and return, his brain has received no activating stimuli, there can be no change in the pulse. No record of the operation has been written either upon the subconscious brain or the conscious brain.

The benefits do not end, however, with the immediate results. *The post-operative hyperthyroidism is prevented or minimized,* and the later clinical results are improved to the same extent as are the *immediate* results.

CHAPTER XXIII

THE TREATMENT OF EMERGENCIES

The whole teaching in this book is directed towards the administration of anæsthetics in such a manner that the occurrence of acute emergencies and crises may be foreseen and prevented; but in certain operations and in "bad subjects" for the administration, respiratory obstruction, respiratory central failure, and cardiac failure, may arise from a combination of adventitious circumstances not wholly within the anæsthetist's control.

RESPIRATORY FAILURE.—All the minor difficulties in respiration have been alluded to, and their treatment indicated (p. 23 *et seq.*).

From whatever cause it arises—*i.e.*, from obstruction within or without the respiratory mechanism —cyanosis is due to want of air, and its treatment when markedly developed is always practically the same—*i.e.*, to clear the airway and perform efficient artificial respiration. A modified Howard's method of artificial respiration, after opening the mouth and drawing the tongue forward, consists in making regular pressure upon the lower part of the sternum with the hand at intervals of a few seconds, thereby causing the elastic recoil to refill the chest with air. Another suitable method in anæsthesia is Sylvester's. In this the head is first lowered and extended backwards,

the mouth opened and tongue drawn out; now the patient's arms are grasped above the elbows from behind and, by a downward movement, are made to compress the chest walls, causing a strong expiration, then drawn outwards and upwards till the hands meet above the head, causing deep inspiration. These movements are repeated regularly about fifteen times a minute until efficient natural breathing is resumed (Plate VIII., Figs. 1 and 2).

On p. 26 will be found the method of treating laryngeal spasm; but if mechanical occlusion has occurred, the head must now be lowered, or, in the sitting position,

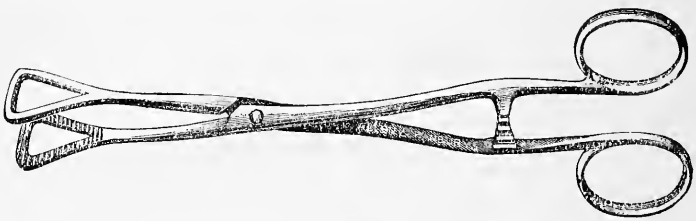

Fig. 36.—Tongue Forceps: Guy's Pattern.

bent well forward. The finger should be passed to the back of the throat, any solid obstruction felt for and swept forwards towards the teeth, and further sponging and chest compression used if fluid be the cause.

Should these be of no avail, laryngotomy must be immediately performed, preferably by the operator; but, as it may devolve upon the anæsthetist, he should always carry an emergency case, containing laryngotomy and tracheotomy tubes, hooks, and a scalpel, with his other apparatus, in case of need.

If a general spasm of the chest walls still persist, artificial respiration by Sylvester's method must be

FIG. 1.—SYLVESTER'S METHOD OF ARTIFICIAL RESPIRATION.

Patient's head lowered and extended. Tongue drawn forward.
First Movement.—Compression of lower ribs, causing *expiration* of anæsthetic vapour from the lungs.

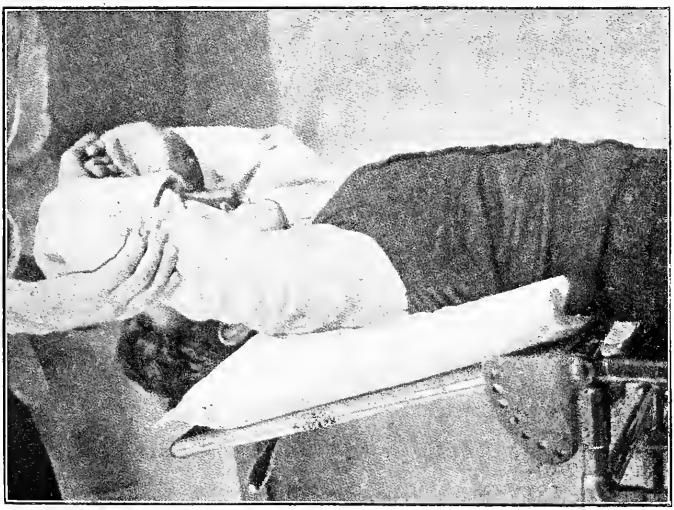

FIG. 2.—SYLVESTER'S METHOD OF ARTIFICIAL RESPIRATION.

Second Movement.—Arms drawn outwards, and then extended, causing expansion of chest walls and *inspiration* of air into lungs.

To face page 206.

performed, and there is then little doubt that natural respiration and recovery will ensue. Inflation of the lungs by the administrator may also be used by a tube inserted into the larynx, or by mouth-to-mouth perflation in the case of children.

In dental operations the extractor must be extremely careful to remove from the mouth every particle of tooth as he loosens it, but the anæsthetist should also guard the back of the throat with his fingers, Carter's oral net spoon, or a sponge held behind the tooth, to prevent its falling into the throat in case it should accidentally shoot out or fall from the forceps.

If a portion of a tooth enter the larynx, trachea, or bronchus, the patient's back must be vigorously slapped, with the object of dislodging it. Then he should be laid on the floor semi-prone and the chest squeezed; then inversion of the patient may be tried, and laryngotomy and artificial respiration afterwards, if these fail.

Tight corsets and belts, fluid in the chest or abdomen, and bad postures, preventing lung expansion, may bring about respiratory failure in anæsthesia, and these must be removed or corrected as they are discerned to be the cause by the administrator, artificial respiration being resorted to, if need be, to restore the normal breathing first.

If the corneal reflex disappear altogether and respiration becomes feeble, with increasing cyanosis, toxic paralysis of the medullary centre is to be suspected by the anæsthetist. Artificial respiration, with the mouth open and tongue drawn forward, must be performed at once, and persisted in till breathing recommences.

Anæmia of the respiratory centre is sometimes the cause of failure, if the head be much raised under chloroform or considerable hæmorrhage has taken place during the operation. This should be treated by lowering of the head and raising the feet to refill the depleted cerebral vessels.

CIRCULATORY FAILURE.—This is most common under chloroform, and is always best treated by first lowering the head; rubbing the lips briskly will then stimulate the respiration and improve the circulation by the deeper breathing aiding the heart in its work. Pallor, especially of the nose and in the line of the facial arteries from the mandible towards the alæ nasi, is a marked sign of circulatory failure. If not due to impending sickness, the corneal reflex being absent, failing circulation must be at once treated by artificial respiration, because this eliminates the anæsthetic rapidly from the system through the lungs.

If the heart failure deepens while artificial respiration is continued, the operation must of course be stopped, the feet raised, and regular rhythmic traction made upon the tongue. Intermittent attempts should also be made to squeeze the paralyzed cardiac ventricles between the fingers inserted beneath the ribs in the epigastric region and the chest wall.

Hypodermic injections of pituitrin may be used. Electricity may quite possibly inhibit rather than stimulate a feebly acting heart.

Hot saline solution or brandy may be given by the rectum, but the main restorative is *efficient* artificial respiration.

CHAPTER XXIV

THE DUTIES OF THE NURSE AND AFTER-TREATMENT

All patients should be laid on the side in bed to recover from anæsthesia, or, if this be not possible, one shoulder should be raised with a pillow, and the head turned to the opposite side as far as possible. This prevents the tongue falling backwards and blocking the airway, and vomited fluids from being inhaled into the trachea.

To keep a patient upon the side, his lower leg may be straight, but the upper leg must be bent and the knee drawn forward. A pillow behind the shoulders will then keep him in place.

There are several important duties to be observed by those left in charge of patients recovering from surgical anæsthesia.

These are directed towards the maintenance of a clear airway in the upper respiratory passages, especially in connection with the act of vomiting while the patient is still semi-conscious.

This can be managed by turning the patient's head to the side, and passing the index-finger between the patient's lips and along the margin of the upper jaw towards the molar teeth, which allows air to pass into the mouth over the side of the tongue. Sometimes, also, the finger can be inserted between the jaws behind

the last teeth, and the jaws can be thus separated without the use of a jaw-gag. The latter should, however, be at hand in all hospital cases, where patients are earlier left to the nurse's care.

A good plan when the operation has involved the upper air-passages, and the nose or throat may become invaded with blood, or the stomach was not empty of solid food beforehand, is to insert a disused cotton reel, tied to a foot-length of strong tape or string, between the side-teeth as soon as the patient is back in bed, which will prevent any mechanical obstruction to breathing arising from clenching of the jaws. This forms an excellent mouth-prop. If the patient has been in the feet-up position during operation, the bed's foot should be raised by means of blocks during recovery, to prevent faintness from cerebral anæmia by the change of posture.

If there be any respiratory râles—*i.e.*, moist sounds in the chest or throat—the patient should be encouraged to cough from time to time until the air-passages and bronchial tubes are clear, for neglect of this precaution leads to bronchitis and pneumonia.

Half an hour after recovery of consciousness, patients may be propped up in bed for this purpose, if the breathing has been difficult when lying down. If this be impossible, one lung may be cleared at a time by turning the patient first on to his left side for a time, and then upon the right, as the upper lung then drains and expands more efficiently.

As explained elsewhere, there should be no hot bottles left in the bed during recovery from an anæsthetic, until complete sensibility is regained, on account of the danger of burning the insensitive skin which they may touch.

Heat is best applied by means of warmed blankets next the skin.

After-vomiting from anæsthetic inhalation should be encouraged if blood has been swallowed in air-passage operations, especially in children, who often remain faint for some while if blood remain in the stomach.

Ether vomiting may be restrained by constant sips of hot water, and the taste of ether removed by allowing thin slices of lemon to be held between the lips.

Acidosis

A condition following operations under chloroform, especially in children, which was first described in 1850 by Langenbeck as chronic chloroform poisoning, has received much attention in recent years since Dr. Leonard Guthrie wrote an account of "Some Fatal After-Effects of Chloroform in Children."[1] Dr. Guthrie described the symptoms thus:[2]

The classical symptoms of delayed poisoning by chloroform, and, we may add, by other anæsthetics, are now recognized as those of acute fatty acid intoxication.

After recovery from the immediate effects of the anæsthetic there is usually a period of lull lasting from twelve to thirty-six hours during which nothing amiss will be noted. Then follows a term of wild excitement in which the patient utters piercing cries at short intervals, grinds the teeth, tosses and struggles, and

[1] *Lancet*, 1894, vol. i., p. 193.

[2] "Transactions of the Society of Anæsthetists," vol. viii., p. 120, "Delayed Poisoning by Anæsthetics."

requires constant attention, lest dressings should be torn off, or fractured bones displaced. The pupils are often dilated, sometimes unequally, the face may be pale or flushed, the expression anxious or terrified, consciousness may be lost early and never regained. But sometimes the delirium alternates with drowsiness, apathy and dulness. The patient will answer rationally when addressed, and usually denies being in pain.

The eyes become sunken, the face haggard, and the abdomen retracted. Thirst is intense, emaciation is rapid. Sometimes screaming, maniacal delirium, and restlessness quickly subside, unconsciousness deepens to coma, and death occurs from gradual failure of the heart and respiration. Meningitic or diabetic coma may be suspected. In some, the stage of excitement and restlessness ends suddenly in death from cardiac failure. In some, cerebral excitement is absent; death is due to sudden collapse. Dyspnœa, or air hunger, with cyanosis, are occasionally present. The respirations may be sighing or irregular, or of Cheyne-Stokes' variety.

In cases which are perhaps most typical, jaundice is observed. But jaundice on the whole is rare, and when present the symptoms are those of acute yellow atrophy of the liver. Petechiæ on the skin have occasionally been noted. Pyrexia is uncommon, but the temperature may rise from normal or thereabouts to 105° F. or 106° F. or even higher as the end approaches, especially in cases which terminate rapidly.

The pulse is quickened and may become uncountable, weak and irregular. Vomiting is probably the

earliest and most characteristic symptom. It is usually copious, frequent, and persistent. At first it consists of watery and sometimes bile-stained mucus, gastric juice, and succus entericus. Sooner or later the vomit resembles the dregs of beef-tea or coffee-grounds, owing to the presence of blood, and this black vomit is characteristic of the condition under consideration. The urine may be scanty; it is rarely suppressed, but may be retained. Albumen and casts may be found in it, although absent before operation.

Last and by no means least, acetone is almost invariably present in the urine, and the smell of acetone is noticeable in the breath. Sometimes the urine also contains diacetic acid.

The duration of the symptoms varies. They may prove fatal in twelve hours or within a week from the administration of the anæsthetic. The average duration is three or four days.

Post-Mortem Appearances.—The most characteristic and almost invariable appearance after death due to delayed chloroform poisoning is in the liver. The organ is strikingly pale. Sometimes it is of a bright canary colour, sometimes it is fawn-coloured, studded and streaked with minute purple specks and lines. It may be large, normal, or reduced in size. It is intensely fatty, and if sections are stained with sudan or osmic acid, the liver cells are seen to be crowded and distended by oil globules of various sizes. Sometimes the fat is most evident in the central, and sometimes in the peripheral part of the lobules.

The nuclei of the cells usually, but not always, stain well with hæmatoxylin; occasionally they show signs of cloudy degeneration.

Anæsthesia by chloroform is particularly dangerous in the presence of **acute acetonuria,** though less harmful in cases of **chronic acetonuria,** because the kidneys have become used to eliminate the noxious products of fatty metabolism.

The practical conclusions offered are:—(1) Operations should be delayed when possible if a fatty liver be suspected. It may be suspected in subjects of rickets and infantile paralysis who have been overfed with fattening food and under-exercised, in cases of sepsis and diabetes, and when a history of cyclical vomiting is obtained.

(2) When a child has recently vomited, apparently without cause, an intended operation should be postponed.

(3) When fatty liver is suspected, the patient should be kept for some days on a diet restricted in fats.

(4) Bicarbonate or citrate of soda should be given meanwhile in order to neutralize fatty acids which may be present. Mild purgation may be beneficial.

(5) Starvation will give rise to acute acetonuria; therefore nutrient enemata should be given two hours before and immediately after an operation.

(6) Although any general anæsthetic may be dangerous in the presence of a fatty liver, chloroform is most dangerous of all, on account of its specific action on the liver and kidneys.

The treatment of acid intoxication following operations should be by venesection, saline transfusion, and by clysters of bicarbonate of sodium.

Chloroform vomiting, especially in cases of acute septic infection and in children, may be prevented, where acetonuria previously exists, by the adminis-

tration of tablets of glucose (containing 10 grains for children, or 1 drachm for adults) four-hourly for twelve doses before operation.[1]

Sodium bicarbonate should also be freely given afterwards in doses of 10 to 15 grains in a tumblerful of hot water six or seven times a day, and saline infusions and stimulants resorted to in persistent cases, to compensate for fluid lost by vomiting.

[1] F. H. Wallace and E. Gillespie, *Lancet*, December 5, 1908, p. 1666.

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